



DRAFT SAMPLING AND ANALYSIS PLAN: SEDIMENT STUDY SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation
International Paper Company
U.S. Environmental Protection Agency, Region 6

Prepared by

Integral Consulting Inc.
411 First Avenue South, Suite 550
Seattle, Washington 98104

Anchor QEA, LLC
2113 Government Street
Building D, Suite 3
Ocean Springs, Mississippi 39564

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Title and Approval Sheet

Quality Assurance Project Plan Approvals

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Quality Assurance Project Plan Approvals

Geotechnical and
Engineering Laboratory

Project Manager: To be determined _____ Date: _____

Geotechnical and
Engineering Laboratory

QA Manager: To be determined _____ Date: _____

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LIST OF ACRONYMS AND ABBREVIATIONS

Anchor QEA	Anchor QEA, LLC
ASTM	American Society for Testing and Materials
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CDF	confined disposal facility
COC	chain-of-custody
COI	chemical of interest
COPC	chemical of potential concern
CLP	Contract Laboratory Program
CSM	conceptual site model
CU triax	consolidated-undrained triaxial
DQO	Data Quality Objective
EDD	electronic data deliverable
EDL	estimated detection limit
EqP	equilibrium partitioning
ERL	effect range low
FS	Feasibility Study
FSP	Field Sampling Plan
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRGC/HRMS	high-resolution gas chromatography with high-resolution mass spectrometry
HASP	Health and Safety Plan
I-10	Interstate Highway 10
Integral	Integral Consulting Inc.
IPC	International Paper Company
Koc	partition coefficient of a chemical in the organic matter of soil/sediment
Kow	octanol-water partition coefficient

MIMC	McGinnes Industrial Maintenance Corporation
MDL	method detection limit
MRL	method reporting limit
NPL	National Priorities List
NTCRA	Non-Time-Critical Removal Action
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy or bias, representativeness, completeness, comparability
PCB	polychlorinated biphenyl
PRG	Preliminary Remediation Goal
PSCR	Preliminary Site Characterization Report
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RME	reasonable maximum exposure
RI	Remedial Investigation
RPD	relative percent difference
SAP	Sampling and Analysis Plan
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SLERA	screening level ecological risk assessment
SLV	screening level value
SOP	standard operating procedure
SRM	Standard Reference Material
SSI	screening site inspection
SVOC	semivolatile organic compound
TAL	Target Analyte List
TCDF	tetrachlorodibenzofuran
TCEQ	Texas Commission on Environmental Quality
TEQ	toxicity equivalent
TMDL	Total Maximum Daily Load
TOC	total organic carbon

TXDOT	Texas Department of Transportation
UAO	Unilateral Administrative Order
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
VST	vane shear test
WTP	wastewater treatment plant

1 PROJECT MANAGEMENT

1.1 Distribution List

Title	Name
EPA Remedial Project Manager	Stephen Tzhone
EPA QA Reviewer	Walter Helmick
Respondents' Project Coordinator and Anchor QEA Project Manager	David Keith
McGinnes Industrial Maintenance Corp. Project Manager	Andrew Shafer
International Paper Co. Project Manager	Philip Slowiak
Integral Project Manager	Jennifer Sampson
Study Element 1&2 Task Manager	Jane Sexton
Study Element 3&4 Task Manager	John Laplante
Study Element 1&2 Field Lead	Joss Moore
Study Element 3&4 Field Lead	Jason Kase
Laboratory QA Coordinator	Craig Hutchings
Database Administrator	Dreas Nielsen
Chemical Testing Laboratory Project Manager	To be determined
Chemical Testing Laboratory QA Manager	To be determined
Geotechnical and Engineering Laboratory Project Manager	To be determined
Geotechnical and Engineering Laboratory QA Manager	To be determined

1.2 Introduction and Task Organization

This Sampling and Analysis Plan (SAP) has been prepared on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC), pursuant to the requirements of Unilateral Administrative Order (UAO), Docket No. 06-03-10, which was issued by the U.S. Environmental Protection Agency (USEPA) to IPC and MIMC on November 20, 2009, (USEPA 2009a). The 2009 UAO directs IPC and MIMC to prepare a work plan for a Remedial Investigation and Feasibility Study (RI/FS) and a SAP for the San Jacinto River Waste Pits (SJRWP) Superfund Site in Harris County, Texas (the Site). The 2009 UAO also directs IPC and MIMC to submit a screening level ecological risk assessment (SLERA).

As agreed by USEPA on January 20, 2010, the RI/FS Work Plan and SLERA will be submitted on March 31, 2010. This SAP is being submitted prior to the RI/FS Work Plan so that information relevant to the RI, engineering evaluations, and design for a planned Non-Time-Critical Removal Action (NTCRA) at the Site can be collected as early as practical. This SAP addresses only the sampling and analysis of sediments required for the RI/FS, which is the most far-reaching and complex field investigation anticipated for the RI/FS at the Site. This document is the SAP, and consists of this Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP), which is included as Appendix A. The QAPP was prepared consistent with USEPA guidance and requirements for QAPPs (USEPA 1998, 2001), as required by the 2009 UAO. Additional SAPs setting forth the QAPPs and FSPs for sampling of other media (e.g., biological tissue, soils) will be submitted according to the schedule provided in the RI/FS Work Plan.

This section reviews the organizational structure for activities associated with the sediment study, including project management and oversight, field work, sample analysis, and data management. The organizational structure for this project is illustrated in Figure 1. Contact information for key personnel is provided in Section 1.3.

1.3 Project Organization

IPC and MIMC have retained Anchor QEA, LLC (Anchor QEA) and Integral Consulting Inc. (Integral) to perform the RI/FS. Figure 1 illustrates the organization of personnel on the project. The primary contacts for USEPA, MIMC, and IPC are provided in the next table. A description of the project organization and contacts pertaining to this QAPP are provided after the table.

USEPA and Respondent Project Managers

Title	Name	Contact Information
USEPA Remedial Project Manager	Stephen Tzhone	U.S. Environmental Protection Agency, Region 6 1445 Ross Avenue Dallas, TX 75202-2773 (214) 665-8409 tzhone.stephen@epa.gov

Title	Name	Contact Information
McGinnes Industrial Maintenance Corporation Project Manager	Andrew Shafer	800 Gessner, Suite 1100 Houston, TX 77024 (713) 647-5460 dshafer@wm.com
International Paper Company Project Manager	Philip Slowiak	6400 Poplar Avenue Memphis, TN 38197-0001 (901) 419-3845 philip.slowiak@ipaper.com

The sediment study is organized into four study elements, as described in Section 1.9. These correspond to the broader Study Elements 1 through 4 described in the RI/FS Work Plan. To execute this study, Anchor QEA and Integral will conduct the field work and data analysis, with Integral primarily responsible for execution of Study Elements 1 and 2, and Anchor QEA responsible for execution of Study Elements 3 and 4. The names and quality assurance (QA) responsibilities of key project personnel for Anchor QEA and Integral who will be involved in sampling and analysis activities are provided below.

Project Personnel Quality Assurance Responsibilities

Title	Responsibility	Name	Contact Information
Project Coordinator	Coordination of project information and related communications on behalf of IPC and MIMC with USEPA; liaison between USEPA project managers and respondent project managers	David Keith	Anchor QEA, LLC 2113 Government Street Building D, Suite 3 Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com
Anchor QEA Project Manager	Project planning and implementation; liaison between respective internal and external team members and project coordinator	David Keith	Anchor QEA, LLC 2113 Government Street Building D, Suite 3 Ocean Springs, MS 39564 (228) 818-9626 dkeith@anchorqea.com

Title	Responsibility	Name	Contact Information
Integral Project Manager	Responsible for the successful completion of tasks associated with Study Elements 1 and 2 and coordination with the Anchor QEA project manager, the IPC project manager, and the MIMC project manager to execute the study described in this SAP	Jennifer Sampson	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0351 jsampson@integral-corp.com
Anchor QEA and Integral Corporate Health and Safety Managers	Oversight of health and safety program for field tasks associated with RI/FS	David Templeton	Anchor QEA, LLC 1423 Third Avenue, Suite 300 Seattle, WA 98101 (206) 287-9130 dtempleton@anchorqea.com
		Eron Dodak	Integral Consulting Inc. 319 SW Washington Street Suite 1150 Portland, OR 97204 (503) 284-5545 edodak@integral-corp.com
Study Elements 1 and 2 Integral Task Manager	Data Quality Objective (DQO) planning, QAPP development, and ensuring the project objectives for Study Elements 1 and 2 are met; liaison between project manager and project team	Jane Sexton	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0342 jsexton@integral-corp.com
Study Elements 3 and 4 Anchor QEA Task Manager	DQO planning, QAPP development, and ensuring the project objectives for Study Elements 3 and 4 are met; liaison between project manager and project team	John Laplante	Anchor QEA, LLC 1423 Third Avenue, Suite 300 Seattle, WA 98101 (206) 287-9130 jlaplante@anchorqea.com
Study Elements 1 and 2 Field Lead Integral	Field data collection and implementation of the Health and Safety Plan in the field for Study Elements 1 and 2	Joss Moore	Integral Consulting Inc. 319 SW Washington Street Suite 1150 Portland, OR 97204 (503) 284-5545 jmoore@integral-corp.com
Study Elements 3 and 4 Field Lead Anchor QEA	Field data collection and implementation of the Health and Safety Plan in the field for Study Elements 3 and 4	Jason Kase	Anchor QEA, LLC 4208 Cherry Laurel Drive Pensacola, FL 32054 (850) 912-8400 jkase@anchorqea.com

Title	Responsibility	Name	Contact Information
Project Database Administrator Integral	Database development and data management	Dreas Nielsen	Integral Consulting Inc. 411 1st Avenue South Suite 550 Seattle, WA 98104 (206) 957-0311 dnielsen@integral-corp.com
Project Laboratory QA Coordinator Integral	Completeness of QA documentation and procedures; liaison between project personnel, laboratories, and data validators and for related QA communications with USEPA	Craig Hutchings	Integral Consulting Inc. 1205 West Bay Dr. NW Olympia, WA 98502 (360) 705-3534 chutchings@integral-corp.com

1.3.1 Laboratories

The following responsibilities apply to the project manager and QA manager at the analytical laboratories used for this task.

The laboratory project manager is responsible for the successful and timely completion of sample analyses, and for performing the following tasks:

- Ensure that samples are received and logged in correctly, that the correct methods and modifications are used, and that data are reported within specified turnaround times.
- Review analytical data to ensure that procedures were followed as required in this QAPP, the cited methods, and laboratory standard operating procedures (SOPs).
- Keep the task QA coordinator apprised of the schedule and status of sample analyses and data package preparation.
- Notify the task QA coordinator if problems occur in sample receiving, analysis, or scheduling, or if control limits cannot be met.
- Take appropriate corrective action as necessary.
- Report data and supporting QA information as specified in this QAPP.

The laboratory QA manager is responsible for overseeing the QA activities in the laboratory and ensuring the quality of the data for this project. Specific responsibilities include the following:

- Oversee and implement the laboratory's QA program
- Maintain QA records for each laboratory production unit
- Ensure that QA and quality control (QC) procedures are implemented as required for each method and provide oversight of QA/QC practices and procedures
- Review and address or approve nonconformity and corrective action reports.

Coordinate response to any QC issues that affect this project with the Laboratory Project Manager.

1.4 Problem Definition and Background

On March 19, 2008, USEPA added the Site to the National Priorities List (NPL), and the 2009 UAO requires that a RI be conducted at the Site. The investigation described in this SAP will address uncertainties about the following aspects of the Site:

- The nature and extent of Site-related sediment contamination
- The exposure to humans and ecological receptors that may be using the Site and may be in direct or indirect contact with contaminated sediment
- The physical characteristics of the Site and physical processes governing fate and transport of Site-related contaminated sediments
- The physical properties of sediment that are directly adjacent to the impoundments and that may provide the basis for construction of facilities for containment of the wastes in the future

The remainder of this document describes the Site history and conceptual site model (CSM), identifies the chemicals of interest (COIs) and chemicals of potential concern (COPCs), provides a design for the collection and analysis of new information to address and reduce these uncertainties, and describes the sampling procedures, sample custody, analytical procedures, data validation, reporting and management, and QA procedures. Appendix A, the FSP, describes in detail the sampling and data gathering methods, station positioning, field documentation, and all sample handling details. It includes field SOPs and an addendum specific to this study for the project Health and Safety Plan (HASP; Anchor QEA 2009).

1.4.1 Site History

The Site consists of a set of impoundments approximately 14 acres in size, built in the mid-1960s for disposal of paper mill wastes, and the surrounding areas containing sediments and soils potentially contaminated with the waste materials that had been disposed of in the impoundments. The set of impoundments is located on a 20-acre parcel on the western bank of the San Jacinto River, in Harris County, Texas, immediately north of the Interstate Highway 10 (I-10) Bridge over the San Jacinto River (Figure 2).

In 1965, the impoundments were constructed by forming berms within the estuarine marsh, just north of what was then Texas State Highway 73, and is now I-10, to the west of the main river channel. The two primary impoundments at the Site were divided by a central berm running lengthwise (north to south) through the middle, and were connected with a drain line to allow flow of excess water (including rain water) from the impoundment located to the west of the central berm, into the impoundment located to the east of the central berm (Figure 2). The Screening Site Inspection (SSI) Report (TCEQ and USEPA 2006) states that a series of three or more surface impoundments were used to dispose of wastewater treatment sludge.

In 1965 and 1966, pulp and paper mill wastes (both solid and liquid) were reportedly transported by barge from the Champion Paper Inc. paper mill in Pasadena, Texas, and unloaded at the Site into the impoundments. The Champion Paper mill used chlorine as a bleaching agent, and the wastes that were deposited in the impoundments have recently been found to be contaminated with polychlorinated dibenzo-*p*-dioxins, polychlorinated furans (dioxins and furans), and some metals (TCEQ and USEPA 2006); additional discussion of the chemical constituents typical of materials like those deposited in the impoundments is provided in Section 1.5. The impoundments were used for waste disposal from September 1965 through May 1966. In a letter dated July 1966, the Texas Water Pollution Control Board stated that it was their understanding that no additional waste material would be placed in the impoundments.

Physical changes at the Site in the 1970s and 1980s, including regional subsidence of land in the area due to large scale groundwater extraction and sand mining within the river and marsh to the west of the impoundments, have resulted in partial submergence of the berms

and exposure of the contents of the impoundments to surface waters. Based on permit reviews, aerial photo interpretation, recent bathymetric survey results, and an evaluation of the distribution of dioxin in surface sediments surrounding the Site, it appears sand mining-related dredging by third parties occurred in the vicinity of the perimeter berm at the northwest corner of the impoundments in 1997 or 1998. On the basis of aerial photographs, materials dredged during this time appear to have been placed onto an adjacent upland area (referred to herein as “the Big Star Property”) immediately to the west of the dredged area and impoundments. These dredging activities appear to have directly compromised the integrity of the berms on the northwestern portion of the impoundment, as they were undermined, and resulted in dispersion of dioxin-contaminated materials to surrounding sediments in the river and potentially to adjacent upland soils. It appears that once the sediments were taken to the upland portion of the Big Star Property, materials were sorted to extract sands. The dredging activity also appears to have contributed to the erosion and disappearance of the perimeter berm on the northwest side of the Site, and possible subsequent distribution of dioxin and furan-contaminated sediments from inside the impoundments to areas west and northwest of the impoundments, and into the uplands. Recent samples of sediment in nearby waters north and west of the impoundments (University of Houston and Parsons 2006) indicate that dioxins and furans are present in nearby sediments at levels higher than levels in background areas nationally (USEPA 2000).

Current land use and planned zoning and parcel boundaries are shown in Figure 3. Residential, commercial, industrial, and other land use activities occur within the Preliminary Site Perimeter and the Study Area. Residential development on the eastern bank of the river is present within 0.5 mile of the Site. The impoundments are currently occupied by late successional stage estuarine riparian vegetation to the west of the central berm, and are consistently submerged even at low tide to the east of the central berm. The Big Star Property areas to the west of the impoundments, where sediments were processed after dredging, are denuded and covered with crushed cement and sand, with the perimeter of the graded industrial upland area above high tide populated by estuarine riparian vegetation. Estuarine riparian vegetation also lines the upland area that runs parallel to I-10. A sandy intertidal zone is present along the shoreline throughout much of the Site (Figure 2).

1.4.2 Summary of Available Sediment Data

Both chemical and physical data describing conditions at the Site are currently available. A summary of each of these two types of available information is provided below.

1.4.2.1 Existing Sediment Chemistry Data

The Preliminary Site Perimeter identified in the 2009 UAO is within the estuarine portion of the lower San Jacinto River, in an area from which sediments have previously been sampled for several studies (Table 1 and Figure 4). The Preliminary Site Perimeter occurs within a larger Study Area (Figure 5). The Study Area is the area within which sediment samples have been or may be collected and analyzed to address the objectives of one or more study elements for the RI/FS. The studies or programs providing sediment chemistry data include the following:

- The SSI Report (TCEQ and USEPA 2006)
- Sampling for the I-10 dolphin project (Weston 2006)
- The Houston Ship Channel dioxin Total Maximum Daily Load (TMDL) study (University of Houston and Parsons 2006)
- Samples collected for Texas Commission on Environmental Quality (TCEQ) in August 2009 (URS 2010)
- Data generated by the November 1, 2009, Permit Evaluation Process initiated by USEPA, U.S. Army Corps of Engineers (USACE), and TCEQ, and managed by TCEQ (USEPA et al. 2009); this currently includes a dataset for one permit application (Orion 2009)
- The Houston Ship Channel Toxicity Study (ENSR and EHA 1995)

Within the Preliminary Site Perimeter, surface sediment samples have been collected from 46 locations, and sediment cores have been collected from five locations for the studies listed above (Table 2 and Figure 4). In some cases, a location was sampled more than once, so more than 46 individual surface sediment samples are represented in the database. Eight of the surface sediment sample locations are within the impoundments or in their immediate vicinity near the I-10 Bridge. The highest spatial density of samples within the Preliminary Site Perimeter is in and adjacent to the impoundments and adjacent to the I-10 Bridge (Figures 4 and 6). Sediment samples collected within the Site upstream of the impoundments

are approximately 1,000 feet (305 m) apart. Within the Site and Study Area under or downstream of the I-10 Bridge, 25 samples were collected but 16 of these are not within the Site boundary and 15 are closely spaced around the Sneed Shipbuilding facility. Louchouart and Brinkmeyer (2009) also collected samples for analysis of dioxins and furans and organic carbons (OC) in one surface grab sediment sample, and in one 1-m (3-foot) core from within the impoundments and sectioned at 2-cm (0.8-inch) intervals, but these data could not be accessed in time for this evaluation.

Surface sediment chemistry samples from 45 of the Site locations and all of the cores (Table 2) were collected in 2000 or later, and they are considered to represent current conditions, or baseline, for the RI (Table 2). All of these samples were analyzed for dioxins and furans; metals and other chemicals were also analyzed in sediment from 17 surface and four subsurface locations within the Site, and at five locations within the Study Area, but outside the Site (Table 3). Data for pesticides, polychlorinated biphenyls (PCBs), and many semivolatile organic compounds (SVOCs) in surface sediments were generated by TCEQ and USEPA (2006) and by Weston (2006) (Table 3). In most of these samples, none of these chemicals (other than dioxins, furans, and metals) were detected, with very few exceptions.

Upstream sediments in the San Jacinto River have likely influenced sediment conditions within the Site and can be expected to continue to influence them in the future. Measurements of regional background conditions in sediments from the San Jacinto River estuary are therefore relevant to interpreting data from the Site and selecting appropriate remedial actions, if required. Tidal dispersion may lead to some upstream transport and mixing, but the aggregate downstream movement of the sediment in the San Jacinto River system appears to limit the potential influence of downstream sediments on conditions within the Site (Louchouart and Brinkmeyer 2009).¹ The confluence of the Houston Ship Channel with upper Galveston Bay at the San Jacinto Monument, approximately 5 miles downstream of the impoundments, is therefore considered to be the downstream limit of the local sediment data relevant to interpretation of data from the Site (Figure 5). It is considered the downstream limit of the Study Area as well. The extent of this area

¹ Additional discussion of data on the sources and movement of contaminated sediment is provided in the RI/FS Work Plan.

corresponds to the area subject to the November 2009 Permit Evaluation Process initiated by USEPA, USACE, and TCEQ for evaluation of dredged materials (USEPA et al. 2009).

Within the Study Area but outside of the defined Site boundary, sediment samples were collected from 26 locations (two locations are not shown on Figures 4 and 6 because they are farther upstream than the extent of this map). All but two of these locations were sampled in 2000 or later (Table 2). All of these samples were analyzed for dioxins and furans. Metals and other chemicals were measured in five of them (Table 3). Finally, one dataset was generated for USEPA et al. (2009), but it does not provide concentrations of individual dioxin and furan congeners. This data is not included in the existing baseline data set because toxicity equivalent (TEQ) concentrations were calculated using a 1989 toxicity equivalency factor scheme, and the dioxin and furan congener data were not available in time for this evaluation. These samples were collected at a facility directly east of the Sneed Shipbuilding site (Orion 2009).

1.4.2.2 Existing Physical Data

Existing physical data include Site bathymetry and geotechnical studies that were performed for the Texas Department of Transportation (TXDOT), which were associated with the I-10 Bridge crossing at the San Jacinto River (Weston 2006). In addition, a 2009 bathymetric survey was conducted around the area that was dredged as part of the sand mining activities that occurred to the west and north of the impoundments (Hydrographic Consultants 2009). Also, there is limited TXDOT bathymetric survey data (date unknown) associated with the dolphin project in the vicinity of the I-10 Bridge.

Although the Hydrographic Consultants bathymetry provides the most recent survey coverage of bed elevations around the impoundments, some deficiencies in this dataset have been identified through visual inspection at periods of low water levels. Additional research would be required to determine the datum, age, and quality of the TXDOT bathymetric survey. The geotechnical data provided by TXDOT provides logs of three geotechnical borings (two in river) south of the I-10 Bridge. These boring logs require some interpretation because they are provided in a non-standard format as part of an engineering plan set. In addition, these borings are not in the vicinity of the historic impoundment

perimeter berms. Additional geotechnical studies may be available from TXDOT; this research is ongoing.

1.4.3 Problem Definition and Overall CSM

Two major physical changes resulted in the exposure of the wastes deposited within the impoundments to surface waters and the distribution of contaminated materials into nearby surface sediments. Land subsidence resulting from groundwater withdrawal in the 1970s contributed to the sinking of the berms. Based on aerial photo interpretations, dredging activities associated with sand mining undermined and damaged the perimeter berm surrounding the northwest portion of the impoundments around 1997 or 1998. As a result of these two events, contaminated material was distributed and became potentially accessible to ecological receptors and to people at the Site. Material from the berm and from within the impoundment was subject to mobilization and redistribution by both the dredging operations and potentially by erosion resulting from tidal and river currents. Dredging activities moved solid material from the impoundment to other locations, including to the west of the impoundments and into the sand separation area on the uplands of the Big Star Property. Mobilization of materials by dredging may also have released sediment-associated contaminants to the water column that would have settled to the bottom. Erosional processes would introduce solids from the uplands directly into the water column, where they could be transported and redeposited elsewhere. Rain and resulting surface water runoff may also transport contaminated upland soils into the water, possibly creating another ongoing source of contamination to the sediment. Determining the spatial extent of sediment contaminants from the impoundments, including in upland soils, is one issue that will be addressed in the RI/FS.

Contact with contaminated sediment within the boundary of the impoundment itself, and in other areas to which it may have been transported, creates the potential for exposure to ecological receptors and for people using the Site. Ecological receptors and people using the Site also may be exposed to contamination from global, regional, and local sources of contamination that are unrelated to the Site. Quantification of exposures to Site-related, upstream, and regional sources of contamination, and resulting risks, is another issue that

will be addressed by the RI/FS. A simple CSM of the release and exposure pathways at this Site is illustrated in Figure 7.

Chemicals associated with the waste impoundments are expected to be exclusively those associated with solid wastes produced by bleached kraft pulp mill operations (Section 1.5.1). Chemistry data for sediment collections from within the area of the impoundments (Table 1) show that dioxins and furans are present in sediments in and near the impoundments at concentrations higher than other Site and regional samples, and may contribute to risks to ecological receptors and people using the Site.

The overall issue to be addressed by the RI/FS, and by sediment sampling in particular, is to determine the horizontal and vertical distribution of pulp mill compounds associated with sediment originating in the impoundments. These data will be used to evaluate the contribution of COPCs to exposure and risks to ecological receptors and people. Both the exposure and risk analyses and characterization of background conditions will be used to develop Preliminary Remediation Goals (PRGs) for sediments, and to support remedy selection. In addition, uncertainty regarding the potential for transport of sediments off the Site, and for transport of upstream sediments into the Site, must be addressed to facilitate the selection of a remedy. Finally, characterization of the physical properties of the sediment surrounding the impoundments is needed to evaluate remedial alternatives that include building a confined disposal facility (CDF) within the Site, at the location of the impoundments.

1.5 Determination of Chemicals of Interest

This section describes the basis for establishing the list of chemicals that will be considered COIs in the RI. Section 1.6 describes how COPCs for the RI are identified, and reports on an analysis of existing sediment chemistry data to define the COPCs. The COPCs will be the chemical analytes in sediments collected for this study.

USEPA guidance for performance of an RI/FS under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA; USEPA 1988a) does not specify the methods to be used to identify COIs and COPCs, nor does it address the specific

chemicals that should be evaluated, regardless of available data, at any individual site. For this project, the process for selection of COIs started with identification of all chemicals on USEPA's Target Analyte List (TAL) for metals and the standard organic analytes (SVOCs, volatile organic compounds [VOCs], pesticides, and Aroclors) and the Contract Laboratory Program (CLP) organics. The combination of these two lists was checked against the Clean Water Act priority pollutants to ensure that all of USEPA's priority analytes were included in the initial evaluation. The final list of the 176 chemicals comprising the priority pollutant list is provided in Table 4.

The primary source of contaminants associated with the Site is the pulp mill sludge deposited in the waste impoundments during operation of the mill in the mid-1960s. Consistent with the CSM, the identification of COIs includes consideration of the constituents likely to be associated with such wastes based on existing sludge sampling and analysis of results from the impoundments. A literature review was conducted relating to pulp and paper mill wastes generated prior to the point at which the paper industry moved away from the use of chlorine ions in its bleaching processes and began using chlorine dioxide.² The literature review is discussed in Section 1.5.1.

To identify COIs, a series of questions was addressed for each chemical individually, as illustrated in Figure 8. A total of 141 chemicals were analyzed in the sediment samples collected by TCEQ and USEPA (2006) from within the impoundments. If an individual chemical was analyzed in these sediments and was detected at least once, it is considered a COI (Figure 8). For those chemicals never detected, and for those priority pollutants never analyzed in sediment from the impoundments, both the likelihood of its presence in the source material (waste from a bleached kraft pulp mill operating in 1965) and the persistence of the chemical were evaluated. Chemical characteristics of bleached kraft pulp mill solid wastes were identified in a literature review (discussed in Section 1.5.1). The persistence of a chemical was evaluated by considering the tendency of each chemical reasonably expected in these pulp mill solid wastes to adsorb to OC in the sediment, as expressed by the Koc value. Chemicals were classified as "persistent" if they were identified in the Hazardous Substances

² In the 1990s, to prevent generation of dioxins and furans, mills stopped using elemental chlorine, which binds with organic materials and forms chlorinated compounds, and switched to using chlorine dioxide, which bleaches fibers and produces no new chemicals (Wiegand 2010, personal communication).

Data Bank as expected to adsorb to suspended solids and sediment based on its Koc and other physical properties (NIH 2010). No additional metrics were used to determine persistence because half-life durations for volatilization or biodegradation of any chemicals not sorbed to sediments were very short in comparison to the 44 years that have elapsed since the wastes were deposited in the estuary (NIH 2010).

As shown in Figure 8, if a chemical on the priority pollutant list was both expected in bleached kraft pulp mill wastes and persistent, it is considered a COI (Table 5). The background information leading to the selection of COIs, and the COI list, are summarized in the rest of this section.

1.5.1 Chemical Characteristics of Bleached Kraft Pulp Mill Wastes

According to available historical documents about the Site, the solid waste materials that were deposited in the impoundments in 1965 had the following characteristics:

- Primarily fibrous (the dried material was reported to resemble low-grade cardboard)
- Near neutral pH
- Medium stiff to stiff
- Low permeability
- Organic base (grass could be grown on the material)

Because there are no data to describe the chemical constituents in the wastes generated by the Champion Paper mill in Pasadena, Texas, at the time the impoundments at the Site were formed, industry experts and technical papers documenting bleached kraft pulp mill waste chemistry were consulted. The description of the types of wastes generated in these mills that follows is a generalized description assembled from these sources.

Several kinds of wastes were generated by bleached kraft pulp mills (NCASI 1999):

- Liquid effluents
- Solid wastes derived from causticizing residuals from the kraft recovery process (lime mud, slaker grits, and green liquor dregs)
- Solids from wastewater treatment plant (WTP) residuals
- Ash generated by burning bark, sawdust, fossil fuels, and in some cases, other waste

materials from a mill site

The chemical constituents of both WTP solids and ash depended to some degree on the types of fiber used to make pulp, and the other materials burned. Generally, the broad categories of hazardous materials expected in bleached kraft pulp mill wastes from that era (Wiegand 2010, personal communication) include dioxins, furans, and chlorinated phenols. The available literature on the hazardous chemicals likely present in bleached kraft pulp mill solid wastes generated in the 1960s is limited; the specific chemicals identified through this research are summarized in Table 6. Table 6 presents those priority pollutants included in the analyses of sediment samples collected from within the impoundments by TCEQ and USEPA (2006), and that may occur in bleach kraft pulp mill wastes according to the literature.

USEPA (1988b) and NCASI (1999) confirm that dioxins and furans were generated historically by bleached kraft pulp mills. A review of available chemistry data for solid wastes generated by 26 bleached kraft and other pulp mills (NCASI 1999) consistently found several types of metals, chlorinated phenols, dioxins, and several volatile organics (Table 6). NCASI (1999) also reports negligible concentrations of PCBs and chlorinated benzenes in some wastes, and trace levels of some polycyclic aromatic hydrocarbon (PAH) compounds in some ash samples. A study of the chemistry of leachates from landfills used specifically for pulp mill wastes (NCASI 1992) reported toluene (a VOC), as well as other phenolics, including three cresol isomers, and trichlorophenols. No pesticides or PCBs were found in these landfill leachates.

A list of analytes provided by Suntio et al. (1988), reporting on the chemical constituents in liquid effluents of pulp mills, included chlorinated phenols, chlorinated benzenes, nitrotoluenes, and 15 VOCs. This paper was consulted, but was not included in Table 6, because the subject was limited to liquid effluents, and liquid wastes were removed from the impoundments at the Site. Leachates from landfills of solid wastes are more likely to be characteristic of any liquid materials associated with the impoundments and were addressed by NCASI (1992).

1.5.2 *Characteristics of Sediments in the Impoundments*

Sediment samples were collected by TCEQ and USEPA (2006) from within the impoundments and analyzed for 141 chemicals, including dioxins and furans, metals, pesticides, SVOCs, and PCBs. VOCs were not analyzed. Pesticides and PCBs were not detected in any samples from the impoundments. SVOCs were also not detected, with the exception of one phthalate compound in one sample. Most metals were detected in one or more samples, with the exceptions of beryllium, selenium, and thallium, which were never detected in sediment samples from the impoundments. Dioxins and furans were detected in all samples from the impoundments.

Louchouart and Brinkmeyer (2009) also collected a sediment grab and a sediment core from within the eastern half of the impoundments in 2006. The only COIs analyzed in these sediments were dioxins and furans, but these investigators also reported on the depth distribution of lignins and several forms of OC within the core, which was sectioned at 2-cm (0.8-inch) intervals. The authors found the OC content of the sediment to be variable at this depth resolution, ranging from about 1 to 3 percent, with a spike in the OC content up to about 8 percent OC at the interval between 1 and 1.3 feet (30 and 40 cm). The materials in this depth appear to contain relatively high fractions of both terrestrial plant-derived lignins and other OC.

Other than dioxins and furans, there were no detectable concentrations of nearly all of the organic chemicals evaluated by TCEQ and USEPA (2006), including the chlorinated phenols, nitrotoluenes, and assorted PAHs that were determined to possibly occur in bleached kraft pulp mill wastes. The confirmed low levels of other organic chemicals, coupled with the very high dioxin and furan concentrations in the sediment and their persistence in the environment, suggest that patterns of dioxins and furans typical of the impoundments may provide a useful signal, or tracer, in the RI/FS for impacts on sediments of material derived from the impoundments.

1.5.3 *Summary of Chemicals of Interest*

A summary of the approach to selection of COIs, and the list of COIs, are provided in Table 7; the final list of COIs is provided in Table 5. COIs are those chemicals that are among

USEPA's priority pollutants, were reported by one or more technical reports as occurring in pulp mill solid wastes or leachate from solid waste landfills, and are likely to have bound to sediment OC and persist for more than 40 years in the environment. These COIs were further evaluated in each of three risk-based screens to identify COPCs, discussed in Section 1.6. Results of the COPC identification affect the sediment sampling and analysis designs, as described in Section 1.7.

1.6 Determination of Chemicals of Potential Concern

Because the source of the COIs to the RI/FS for the Site is the impoundments created in 1965 for the disposal of waste sludges from the Champion Paper mill in Pasadena, Texas (Section 1.4.1), the evaluation to identify COPCs for the RI was performed using chemistry data for the seven sediment samples collected by TCEQ and USEPA (2006) directly from the impoundments. Although there are chemistry data for other sediment samples collected within the Preliminary Site Perimeter (Section 1.4.2), the sediment samples collected from within the impoundments are expected to contain the highest concentrations of any chemicals that are associated with the wastes in the impoundments. This assumption can be verified by comparing the concentrations of dioxins and furans in sediment from the impoundments with the highest concentrations in sediment collected elsewhere from within the Preliminary Site Perimeter. For example, the concentration of 2,3,7,8-tetrachlorodibenzofuran (TCDF) from station 15 in the TCEQ TMDL study was 93,000 ng/kg (the higher of two replicates at this station). The highest concentration in sediment samples outside the impoundments, but still within the Preliminary Site Perimeter is at TMDL station 11 (1,600 ng/kg). This concentration is a factor of nearly 60 lower than the concentration in the impoundments. Therefore, for the purposes of the selection of COPCs, chemical concentrations in sediments at the six stations (seven samples; one a field duplicate) from within the impoundments are considered to represent the highest concentrations of source-related chemicals at the Site.

The process to select COPCs for the RI involves the following two steps:

- Determination of COIs to the investigation (Figure 8)
- Performance of risk-based screens for each COI

To determine whether a COI should be the subject of the sediment investigation, other field investigations that will support the RI/FS, the baseline ecological risk assessment (BERA) and the baseline human health risk assessment (BHHRA), each COI was evaluated using three conservative risk-based screening tools, as follows:

- Human health risk screen
- Fish and wildlife risk screen
- Benthic macroinvertebrate risk screen

The objective of using these screens is to identify those COIs that can be eliminated from further consideration with a high degree of confidence that the COI plays no role in Site-related risks to human health or ecological receptors at the Site. Each of the three risk-based screens combine information on the bioaccumulation potential of each COI, the concentrations of the COI in background areas, and risk-based screening concentrations in sediment to interpret the chemistry of samples from within the impoundments (TCEQ and USEPA 2006). Each risk-based screen results in one of the following conclusions for each COI:

1. Data are sufficient to conclude that there is an absence of risk to receptors using the Site.
2. There are insufficient data to determine whether there is a risk to receptors; more information is needed.
3. Data are sufficient to determine that the COI should be evaluated in the baseline risk assessments.

Those COIs in the first category will not be analyzed further in the RI/FS. A complete evaluation of those COIs in the second category requires additional data, and the extent to which each may contribute to risk is unknown. Additional data are required that describe these COIs in sediment and possibly other media. These chemicals are discussed further in this SAP as “secondary COPCs.” COIs falling into the third category are known to be present in sediments from the impoundments at concentrations associated with the potential for adverse effects to humans, fish, wildlife, or benthic invertebrates. These COIs will be evaluated in the baseline risk assessments, and additional information is required to do so. COIs determined to be in the third category are termed “primary COPCs.”

Each of the three risk-based screens is described below, followed by a summary of the primary COPCs and secondary COPCs that result in Table 8. The entire process and results are summarized for each screen in Tables 8, 9, and 10. Every chemical listed as a primary COPC will be evaluated in one or both of the baseline risk assessments.

Because the comparison to background concentrations is identical for the human health and ecological risk screens, the approach for comparing Site sediments to background is addressed first. Steps to collect and analyze additional information about primary and secondary COPCs in sediments are discussed in Section 1.7 of this SAP. Greater detail on the screening process for ecological receptors will be provided in the SLERA. Additional considerations for planning both the BERA and the BHHRA will be included in greater detail in the RI/FS Work Plan. The sections below are not intended to replace those discussions.

1.6.1 Background Concentrations Used in the Risk-Based Screens

To characterize background conditions for use in both the human health and the ecological screens, three sources of data on chemical concentrations in sediments from background areas were used:

- Background sediment samples collected for the SSI (TCEQ and USEPA 2006: n=4)
- The 85th percentile of tidal stream sediment concentrations from Texas water quality guidance (TCEQ 2003: n≥10)
- The 85th percentile of sediment metal concentrations from the National Uranium Resource Evaluation—Hydrogeochemical and Stream Sediment Reconnaissance data for the Houston quadrangle (USGS 2009: n=41 to 45 per chemical)³

When more than one dataset provided a background concentration to which Site concentrations could be compared, the highest background concentration was selected. If

³ Houston quadrangle data was filtered by limiting the land use type to “other” so as to remove samples that were taken in the vicinity of a potential contamination source (e.g., sites identified as adjacent to agriculture or sewage discharge). Further, chemicals with a high proportion of missing or negative values were filtered out; a subset of metals remained with a sufficient number of values to calculate an upper percentile on the data.

the highest value was a non-detect, it was disregarded and the highest detected value was selected to represent background for comparison to Site concentrations.

1.6.2 Human Health Risk-Based Screen

The approach for evaluating COIs for human health is illustrated in Figure 9. The screening process for a COI considers comparison with its risk-based screening level value (SLV), bioaccumulation potential, whether the COI was ever detected in sediments from within the impoundments, and comparison with background (described above).

SLVs, which were calculated consistent with USEPA (1991) guidance, were obtained from USEPA Region 3.⁴ Human health SLVs are not available for sediment, so SLVs for residential soil were used as surrogates and are considered conservative because residential soil SLVs consider exposures through incidental ingestion, dermal contact, and inhalation of particulates, while direct sediment exposures are likely limited to incidental ingestion and dermal contact. The list of chemicals with potential to bioaccumulate was obtained from TCEQ (2006).

Using this approach, the chemicals identified as primary COPCs for human health are aluminum, copper, mercury, and 2,3,7,8-TCDD TEQ concentrations (Table 8). The chemicals identified as secondary COPCs for human health are magnesium, thallium, 2,3,4,6-tetrachlorophenol, carbazole, and chloroform. Documentation of the human health screening process is provided in Table 9.

1.6.3 Benthic Macroinvertebrate Risk-Based Screen

The approach to evaluating each COI to determine whether it can be eliminated from further assessments of risk to benthic macroinvertebrates on the Site is illustrated in Figure 10. Benthic macroinvertebrates are assumed to be in direct contact with sediments such that chemical concentrations in sediments provide the appropriate measure of exposure for the screening evaluation. SLVs protective of benthic macroinvertebrates were used as a primary screening step in this approach. The primary source of screening values was Long et al.'s Effect Range Low (ERL) values for marine sediments (Long et al. 1995). These

⁴ <http://www.epa.gov/reg3hwmd/risk/human/index.htm>

ERLs represent concentrations of chemicals in sediment that are not associated with adverse biological effects; as such, they provide a conservative screening benchmark against which Site concentrations can be evaluated, consistent with USEPA guidance for selection of screening-level benchmarks (USEPA 1997a). These values are the primary screening values provided in TCEQ ecological risk assessment guidance (TNRCC 2001; TCEQ 2006). If no ERL was available, TCEQ's benchmarks for marine sediments were used as a secondary source of SLVs (TCEQ 2006). Background conditions (described above) are taken into account by this screen, subsequent to comparison with SLVs.

One additional study was considered in identifying benthic invertebrate screening values for PCBs, because the Long et al. (1995) value for PCBs is at odds with more recent literature. Fuchsman et al. (2006) explore the differences between cause-effect studies that are used to derive benthic invertebrate no-effects levels for PCBs in sediment and the screening values derived by Long et al. (1995) and others using data for effects only, and based on sediments containing a mixture of chemicals. Fuchsman et al. (2006) demonstrate that no-effects and effects PCB concentrations in sediment estimated using the equilibrium partitioning (EqP) method are more consistent with actual effects and no-effects values from PCB toxicity studies than the derived screening values such as those of Long et al. (1995). Ideally, the EqP method uses partitioning coefficients for individual congeners, but no-effects concentrations estimated for Aroclors and for total PCBs are also provided by Fuchsman et al (2006). These values are considered conservative, because the more chlorinated PCBs are generally the more toxic, but they are also more likely to be bound to OC in sediments under ambient sediment conditions. These authors list several no-effects levels as $\mu\text{g/kg}$ OC for both marine and freshwater benthic invertebrates. Their lowest unbounded no-observed-effect level (growth) for a PCB mixture is 81 mg/kg OC for a marine clam (*Macoma nasuta*). Conservatively assuming an OC content in sediments from the impoundments of 1.5 percent (Louchouart and Brinkmeyer 2009), the dry weight equivalent of this value is 1.2 mg/kg , which is greater than the highest non-detect for any Aroclor in sediment from the impoundments (TCEQ and USEPA 2006).

Documentation of the screening process for benthic macroinvertebrates is provided in Table 10.

1.6.4 Fish and Wildlife Risk-Based Screen

The approach to determining whether each COI is a COPC, or can safely be eliminated from further assessments of risk to fish and wildlife, is illustrated in Figure 11.

This approach differs from the approach used to identify COPCs for benthic invertebrates because, for the purposes of screening only, fish, birds, and mammals are assumed to be exposed to sediment-related chemicals primarily through ingestion of their foods, or that exposures to COIs for the purpose of evaluating risk would be assessed using whole body or other tissue concentrations, as for dioxins and furans in fish. Therefore, the potential for bioaccumulation of each chemical is considered in the first step of risk-based screening approach for fish, birds, and mammals. Potential for bioaccumulation of metals was evaluated using TCEQ guidance, which lists chemicals considered bioaccumulative (Table 3-1 in TNRCC 2001 and TCEQ 2006). Because TCEQ guidance does not address some of the organic COIs, for all of the organic COIs the log Kow was used as an indicator of bioaccumulation potential. Consistent with USEPA guidance (USEPA 2008c), chemicals with log Kows equal to or greater than 5 were considered to have the potential to bioaccumulate in tissue.

For both the benthic macroinvertebrate and the fish and wildlife screens, maximum concentrations of chemicals with the potential to bioaccumulate were compared to background concentrations (Section 1.6.1).

If the maximum Site concentration was lower than background values, the chemical was not considered a COPC. If the maximum Site concentration or detection limit for a chemical considered bioaccumulative was higher than background values, the chemical was retained for further evaluation in the BERA (Figure 11). If the chemical had never been detected, it was included as a secondary COPC. If it was detected, and met all of the above criteria, it was included as a primary COPC. Documentation of the screening process for fish and wildlife is provided in Table 11. The chemicals identified as primary and secondary COPCs for benthic invertebrates and for fish and wildlife are summarized in Table 8.

1.7 Evaluation of COPCs in the Sediment Study and Its Results

The purpose of investigating chemicals in sediment is to determine the nature and extent of potential contamination, identify any unacceptable risks associated with the contamination, and to evaluate potential remedies (USEPA 2005a). Sections 1.5 and 1.6 describe a series of conservative analyses to focus the RI/FS on only those chemicals that may be present in sediments at levels that could generate unacceptable risks. This section describes how the results of these evaluations will affect the sediment study design and provides an overview of how the results of the sediment study will be analyzed to focus the risk assessments.

Figure 12 provides an overview of how the chemicals listed in Table 4 are addressed and the related analysis steps, including the following:

- Identification of COIs (Section 1.5)
- Application of conservative risk-based screening to select COPCs (Section 1.6)
- Identification of dioxins and furans as an indicator chemical group (Section 1.7.1)
- How the sediment study addresses COPCs (Section 1.7.2).

Because the risk-based screening evaluations were performed on the samples that describe the most contaminated sediments at the Site (i.e., those from the source), the selection and treatment of COPCs described in these sections are applicable to other aspects of the RI/FS. For example, these analyses also define the COPCs and analytes for the investigation of soils in upland areas. Additional information will be provided in the RI/FS Work Plan and subsequent SAPs.

1.7.1 Dioxins and Furans as an Indicator Chemical Group

According to USEPA (1988a) guidance for conducting RI/FS under CERCLA, it is sometimes appropriate to select one or more indicator chemicals to focus the assessment on those chemicals likely to be of greatest concern. An indicator chemical or chemical group is one that is the most toxic, persistent, and/or mobile among those substances likely to contribute significantly to the overall risk at the Site. Selection of an appropriate indicator chemical or chemical group can serve to simplify and focus much of the investigation, the required analyses, and the evaluation of remedial alternatives. Use of an effectively selected indicator

chemical reduces both the costs and the time required to develop and implement a remedial strategy, and in doing so, is considered appropriate by USEPA guidance (USEPA 1988a).

For the Site, dioxins and furans provide an appropriate indicator chemical group for the RI/FS. Their concentrations relative to risk-based screening values are very high in sediments from the impoundments, and the degree to which they exceed risk-based screening levels in these sediments relative to those of the other COPCs is also very high, indicating that they are very likely to be the most important risk driver at the Site. For these reasons, dioxins and furans are the chemicals of greatest concern to the RI/FS. Moreover, concentrations of biologically active congeners can be expressed in a unifying metric, the TEQ concentration, providing a simple means to express exposures, evaluate risks, and to address remedial goals for a group of chemicals. The specific uses of dioxins and furans as an indicator chemical group for the sediment study are discussed in sections below. The overall importance and full range of uses of dioxins and furans as an indicator chemical group will be described in the RI/FS Work Plan.

1.7.2 *How the Sediment Study Addresses COPCs*

Figure 12 outlines the additional analysis steps for the COPCs summarized in Table 8. The sediment study will generate new information on both primary and secondary COPCs in sediments. Primary COPCs will be analyzed in all sediment samples, and secondary COPCs will be included among the analytes in a subset of sediment samples collected for Study Element 1, Nature and Extent Evaluation. Specifically, secondary COPCs will be analyzed in samples from within the impoundments, from a subset of stations within the Site, and in all of the upstream background stations. At all of the stations for which sediments will be collected to characterize the nature and extent of contamination, enough mass of sediment will be collected for analysis of secondary COPCs in these samples. If necessary, this additional mass of sediment will be archived.

To determine whether archived sediments should be analyzed for secondary COPCs, the secondary COPCs in the nature and extent sediment samples will be evaluated using the same risk-based screens applied in Section 1.6. Detection limits will be improved for this study, because a secondary COPC has either never been measured in Site sediments, or was

never detected. In some cases, secondary COPCs will be eliminated from further consideration in the RI because they pass the risk-based screen (Section 1.6).

For each secondary COPC that does not pass one or more of the risk-based screens, the data generated by this sediment study will be evaluated to determine if the concentrations of the secondary COPC correlates with concentrations of the indicator chemical group, dioxins and furans. If the secondary COPC does not correlate, it will be included in the baseline risk evaluation (because it did not pass the risk-based screen). If the secondary COPC does correlate with dioxins and furans, it will not be evaluated in the baseline risk assessments. A correlation with dioxins and furans, the chemicals that are likely the primary risk drivers, will be interpreted to indicate that remedial actions to address dioxins and furans will address any relatively minor risks due to secondary COPCs.

1.8 Uncertainties and Data Gaps

Uncertainties and data gaps currently present in the dataset related to the Site are discussed below. The sediment study proposed in this document addresses the collection and analysis of new information to address and reduce these uncertainties.

1.8.1 Nature and Extent

Surface sediment concentrations of COPCs have been measured throughout the defined Study Area (Figures 4 and 6). The spatial resolution of these samples is fairly low; the average spacing between the samples collected in 2005 in a grid surrounding the impoundments for the TMDL program (University of Houston and Parsons 2006) is approximately 1,000 feet (305 m), and these data are only for dioxins and furans. The steepest spatial gradients of dioxin/furan concentrations are between samples collected from within the impoundment or on the shoreline of the sand separation area on the Big Star Property and samples that are approximately 1,000 feet (305 m) away (Figure 4). At distances greater than approximately 1,000 feet (305 m) from these two locations, the spatial gradient of concentrations appears to be much lower on the basis of the available data (Figure 13). Sediment conditions within 1,000 feet (305 m) of the impoundments and of the shoreline of the sand separation area on the Big Star Property are not well characterized. If remedial alternatives were evaluated with existing information, the spacing of existing

samples in this area would result in a fairly large uncertainty in the spatial extent of any PRG exceedances that might be found in this area.

In addition, concentrations of dioxins and furans in sediment along the eastern and northeastern perimeter of the original impoundments are not well described by the existing dataset (Figure 4). Additional information is needed to characterize sediment chemistry in this area.

Concentrations of metals in sediment have been measured at 17 locations within the Site. Fourteen of these are in or adjacent to the impoundments, or adjacent to the I-10 Bridge to the east of the impoundments. The spatial and vertical distribution of metals is therefore not well characterized and represents data gaps.

The baseline distribution of COPCs with depth is characterized only near the I-10 Bridge. Four sediment cores were collected by Weston (2006), and one core under the Bridge was collected by the TCEQ's TMDL program (University of Houston and Parsons 2006). Therefore, the depth distribution of COPCs throughout the Site is not well characterized. The paucity of sediment core data is a data gap that should be filled to complete an evaluation of the nature and extent of contamination.

The distribution of COPCs in sediments of upstream background areas for baseline is characterized by only five samples from the SSI (TCEQ and USEPA 2006). Therefore, chemistry of upstream sediments is not well characterized. The paucity of upstream sediment chemistry data is a data gap that should be filled to complete an evaluation of the nature and extent of contamination.

1.8.2 Receptor Exposures

Additional data are needed to characterize exposures of humans and ecological receptors to sediment-associated contaminants, both on the Site and for upstream background.

1.8.2.1 *Human Exposure*

There are three human receptor groups of interest for the BHHRA to be conducted for RI for the Site: fishers, recreational visitors, and transient people. These receptor groups may be exposed to sediments via direct contact (ingestion and dermal) or indirectly through consumption of aquatic organisms (i.e., fish and shellfish) that are exposed to the sediments. Available data for COIs in the sediments within the impoundments (TCEQ and USEPA 2006) indicate the presence of dioxins/furans, aluminum, copper, and mercury at levels that are of potential concern to human health (Section 1.6.2). Additional information on the concentrations of these chemicals in sediment at locations throughout the Site where human use activities are expected to occur is needed to reliably characterize exposures and risks to people coming into contact with Site sediment. Additional information on the concentrations of these chemicals in intertidal sediments from upstream in background areas is needed to understand the exposures and risks in background areas.

1.8.2.2 *Ecological Exposure*

A number of fish and aquatic-dependent wildlife species could potentially be exposed to Site-related chemicals through direct contact with contaminated sediments, incidental ingestion of contaminated sediment, or through ingestion of prey organisms that have been exposed to contaminated sediment. The exposure pathway for fish would include exposure at both the nearshore and deeper water environs.

Benthic macroinvertebrates are prey for a wide variety of fish and aquatic-dependent wildlife. Benthic macroinvertebrates known to occur in the vicinity of the Site include crabs, shrimp, mussels, oysters, and clams. Other species adapted to the low-salinity conditions, such as euryhaline polychaetes, oligochaetes, and amphipods, may also be expected in the vicinity of the Site. Fish species that have been listed in association with or collected from the tidal portion of the lower San Jacinto River near the Site include hardhead catfish, red and black drum, Atlantic croaker, gulf killifish, spot, spotted sea trout, and flounder (Gardiner et al. 2008; Osborn et al. 1992; Usenko et al. 2009). Fish and aquatic-dependent wildlife species that have potentially complete direct contact or ingestion exposure pathways from Site-related chemicals include those that prey on benthic

macroinvertebrates, or those that prey on fish that have ingested benthic macroinvertebrates and sediment.

Aquatic-dependent wildlife may nest in, forage in, and/or migrate through the vicinity of the lower San Jacinto River. Birds such as raptors, herons, rails, pelicans, gulls, ducks, and shorebirds; and mammals including raccoon, river otter, nutria, and muskrat use the types of habitats that are present on and in the vicinity of the Site (Litteer 2009; USFWS 2009).

Sandpipers, egrets, and herons are wading birds that forage along shallow intertidal areas for benthic infauna, small fish, and crustaceans. Piscivorous birds foraging in the open waters of the river include terns, cormorants, osprey, and pelicans. Omnivores including gulls and dabbling ducks may forage at the river's edge, as well as in the water column and in the shallow benthos. Nutria and muskrat may be expected in the vicinity in wetland areas with emergent vegetation and river otters may use or move through the area while foraging for prey. Additional mammal species, including opossums and raccoons, may use riparian areas adjacent to the river for foraging and as corridors for moving across territories.

Available data for COIs in the sediments within the impoundments (TCEQ and USEPA 2006) indicate the presence of dioxins/furans, aluminum, magnesium, mercury, and copper at levels that are of potential concern to ecological receptors (Section 1.6.3 and 1.6.4; Table 8).

Additional information on the concentrations of these chemicals in sediment at locations throughout the Site where ecological receptors may be active is needed to reliably characterize exposures and risks to ecological receptors coming into contact with Site sediment. Additional information on the concentrations of COPCs in sediment from upstream background areas is also needed to understand background ecological exposures and risks.

1.8.3 *Physical CSM*

Development of the physical CSM is required to better describe the hydrodynamics and sediment transport within the Study Area. Qualitative and quantitative descriptions of hydrodynamics and sediment transport, which are provided by the physical CSM, are important because these physical processes provide the foundation for understanding chemical fate and transport processes in the Study Area.

For the hydrodynamic component of the CSM, the primary data needs are: 1) geometry and bathymetry both within the Site and upstream; 2) rates of freshwater inflow from the San Jacinto River; 3) changes in water surface elevation (e.g., tidal elevation, including storm surges); 4) current velocity data; 5) salinity and temperature measurements; and 6) wind speed and direction data. For the sediment transport component of the CSM, the primary data needs are: 1) sediment load (magnitude and composition) from upstream in the San Jacinto River; 2) spatial distribution of bed type (e.g., areas of cohesive [muddy] and noncohesive [sandy] sediment); 3) bulk bed property data (e.g., grain size distribution); 4) erosion properties of cohesive sediment; 5) suspended sediment concentrations; and 6) net sedimentation rate measurements. Initially, additional information on sediment grain sizes and dry densities of sediments within and in the vicinity of the Site is required; these data gaps are addressed by the sediment study described in this SAP. Concentrations of COPCs and the grain size of sediments in upstream background areas are also addressed by this SAP.

An evaluation of the data needs for effective sediment transport modeling is underway, and a Sediment Transport Modeling Memorandum will be developed to discuss the modeling and data requirements. The Sediment Transport Modeling Memorandum will be accompanied by an addendum to this SAP for the collection of additional data required for sediment transport modeling. The schedule and timing of this memorandum and sediment transport SAP will be described in the RI/FS Work Plan.

1.8.4 Fate and Transport-Related Information

Sediment transport information will be used in conjunction with chemical data developed for the nature and extent investigation, as well as from the physical CSM, to develop an understanding of chemical fate and transport processes within the Study Area. In addition to chemical concentration data for sediments, additional fate and transport data and information include: 1) chemical loads from the San Jacinto River (e.g., upstream sources); 2) chemical loads from atmospheric deposition; 3) volatilization rates; 4) adsorption-desorption kinetics (i.e., partition coefficients for particle-associated chemicals); 5) porewater concentrations; and 6) total organic carbon (TOC) data. The data relevant to this analysis that will be collected as part of the sediment study described in this SAP includes the data on

the nature and extent of contamination in surface and subsurface sediments, the sediment transport information addressed in the previous subsection, and in the sediment transport SAP referenced therein.

1.8.5 *Engineering-Related Information*

Additional information is required to address the physical properties of sediments surrounding the impoundments to support a full evaluation of remedial alternatives, including the construction of a CDF within the Site.

1.8.5.1 *Geotechnical Data*

A key component of the FS is developing an understanding of how waste pit containment should be reestablished, either through reconstruction of the berms or by other appropriate measures. Additionally, if dredging of sediments in the river is a potential remedial action, the dredgability and materials-handling characteristics of the river sediments should be understood. The information used to evaluate these issues is geotechnical engineering data.

Currently, only limited existing geotechnical studies are available for the project area. As described below, supplemental geotechnical data are required in order to support assessment of the dredgability of river sediments, and to support berm design efforts and the evaluation of construction techniques. Geotechnical data will be used in conjunction with the coastal hydrodynamic modeling results to address potential erosional forces that may influence sediment and berm stability. These different uses of geotechnical data and the associated data gaps are described below.

1.8.5.2 *Dredgability and Dredged Materials Handling*

Physical testing data are required within areas that will potentially be dredged in order to assess the dredging methods, the appropriate dredging equipment, and handling properties of dredged materials. Conceptually, potential dredging may entail the use of hydraulic dredge methods, with placement of dredged material into geotubes staged within the footprint of the CDF proposed to be constructed at the Site. Additional data collection to support evaluation of the behavior of sediments within the geotubes and the CDF will be required

once the prospective dredge area has been delineated by the nature and extent sampling (Section 1.9.1). Any additional studies will be described in an addendum to this SAP. Table 12 provides a summary of the physical testing that is needed to assess dredgability and dredge material handling. Many of these tests also provide information to support the evaluation and design of sediment placement activities within the proposed CDF. Data collection for dredgability and dredge materials handling will be coordinated with the data collection to define the nature and extent of contamination to maximize efficiency of the field sampling program.

1.8.5.3 *Waste Impoundment Containment*

Geotechnical information is required to evaluate engineering considerations for re-establishing containment around the Site and to provide design information for a proposed CDF. Broadly, four categories of subsurface information are required for geotechnical engineering design: conventional geotechnical parameters, soil permeability, soil strength, and soil compressibility. Proposed containment berm side-slopes will need to be designed for static stability under various conditions (e.g., during construction and in the long term). In addition, potential settlement of the subgrade under the berm footprint and within the CDF itself will need to be considered during the FS.

1.9 Task Descriptions

The sediment study will address data gaps by generating new information organized into four related study elements:

- Study Element 1: Nature and Extent Evaluation. Data will be used to characterize the nature and extent of sediment contamination.
- Study Element 2: Exposure Evaluation. Data will be used to evaluate ecological and human health exposure and risks.
- Study Element 3: Physical CSM and Fate and Transport Evaluation. Data will be used to better understand the physical processes governing sediment transport, including the fate and transport of contaminants.
- Study Element 4: Engineering Construction Evaluation. Data will be used to support design of remedial actions, including removal of contaminated sediments and the construction of an on-site CDF.

The broad outlines of each study element are provided in this section. Data Quality Objectives (DQOs) for each element are discussed in Section 1.10; the detailed study design is described in Section 2.

1.9.1 Study Element 1: Nature and Extent Evaluation

Additional data on the horizontal and vertical distribution of COPCs needs to be collected to address the data gaps associated with evaluation of the nature and extent of contamination (Section 1.8). The spatial distribution of these samples should allow the boundary of any PRG exceedances in surface sediment to be determined with a high degree of confidence. The vertical distribution of COPCs in subsurface sediment should be determined with a resolution of 1 foot (30 cm), because this is the finest level of vertical control that is likely to be established in a remedial design. Definition of a remedial action boundary is expected to be made primarily on the basis of PRG exceedances in surface sediment, because surface sediment is the primary source of contaminant exposures medium for ecological receptors and people.

Supplementary pre-remedial sampling may be used in the future to further refine the location of such a boundary and to design a remedy that is both effective and cost-efficient. Characterization of subsurface conditions within a remedial action boundary is expected to require a lower level of spatial resolution than determination of the boundary.

1.9.2 Study Element 2: Exposure Evaluation

Additional information is needed to characterize sediment chemistry in areas where human and ecological receptors may be exposed to sediment-associated contaminants. Surface sediment samples collected for the exposure evaluation will be analyzed for primary COPCs (Table 8), TOC, and grain size.

1.9.2.1 Human Exposure

Surface sediment samples are required for evaluation of human exposures to sediment via direct contact at locations where people could be expected to wade into the water, resulting in direct contact with contaminated sediments in shallow nearshore areas. Data generated

from this study will be used in the BHHRA to characterize direct contact exposures to fishers, recreational visitors, and transients who may be exposed to contaminated sediments from the Site due to direct contact.

1.9.2.2 *Exposure of Ecological Receptors*

Data generated from this study will be used in the BERA to characterize exposure of ecological receptors to contaminated sediments in nearshore, shallow areas of the Site. The data generated by this study will be used to evaluate exposure to ecological receptors resulting from incidental ingestion of contaminated sediment during foraging. Sediment chemistry, TOC, and grain size data collected from nearshore ecological exposure areas will also be used for evaluation of processes resulting in the contamination of tissue of fish and invertebrates dwelling in nearshore shallow areas. Sediment chemistry, TOC, and grain size data collected from deepwater areas of the Site as part of the nature and extent evaluation will be used to evaluate processes resulting in the contamination of biological tissues from those deeper areas. Collection of tissue for the RI will be addressed in a separate SAP.

1.9.3 *Study Element 3: Physical CSM and Fate and Transport Evaluation*

The data and information collected to support the physical CSM and chemical fate and transport evaluation will be used to develop a qualitative narrative that describes chemical fate and transport of sediment-associated contaminants within the Study Area. While there are numerous physical and chemical processes that affect chemical fate and transport at any contaminated sediment site, experience at other sites has shown that a relatively small number of processes are of primary importance. Identifying the primary processes that are controlling chemical fate and transport in the vicinity of the Site is the main objective of this study element. Once the primary processes are determined, the Site-specific physical and chemical data will be integrated and synthesized to develop a coherent narrative that describes chemical fate and transport within the Study Area.

1.9.4 *Study Element 4: Engineering Construction Evaluation*

This study element requires geotechnical information, characterization of dredgability of sediments, and information on the physical properties of sediments adjacent to the impoundments to support design of a CDF.

1.9.4.1 *Geotechnical Evaluations*

Field sampling will address the data gaps identified in Section 1.8. Geotechnical sampling locations are identified in Figure 14. Where possible, river channel sample locations are co-located with chemical sampling core locations.

1.9.4.2 *Dredgability and Dredge Materials Handling*

To address data gaps related to dredgability and materials handling, geotechnical laboratory testing will be conducted on representative sediment samples collected from the river channel. Conventional geotechnical sediment parameters (i.e., moisture content or total solids, grain size, Atterberg limits, and specific gravity) will provide information to evaluate the behavior of sediments to be dredged. These data will be used to consider the appropriate size and types of dredge equipment, expected pumping and dredge production rates, estimated sediment bulking during dredging, and anticipated pre- and post-dredge sediment volumes. Sampling methodology to evaluate dredgability and dredge material handling is described in more detail elsewhere in this SAP and within the FSP.

1.9.4.3 *CDF Design*

Data gaps for CDF and berm design will be addressed by obtaining samples and completing geotechnical laboratory tests, as proposed in Table 12. A series of borings advanced from the upland and from a barge will be used to collect samples. These borings will be advanced at multiple locations in order to provide a representative characterization of the subsurface sediment profile.

Strength data will be used to evaluate bearing capacity and slope stability for the design and construction of the CDF and its containment berms. Vane shear and consolidated-undrained triaxial (CU triax) test results will be used directly as measures of sediment strength. Standard penetration test blow counts and Atterberg limits test results will be correlated to sediment strength using standard-of-practice geotechnical engineering reference sources (e.g., Federal Highway Administration and TXDOT geotechnical manuals).

Settlement data will be used to estimate the magnitude and duration of expected settlement under the footprint of the CDF and its containment berms. The results of this evaluation will be used for planning the crest elevation of the berms and the top elevation of the proposed CDF cap. Consolidation test results will be used as a direct measure of sediment compressibility. Atterberg limits and moisture content data will be used to correlate expected compressibility parameters using similar standard-of-practice geotechnical engineering references as described above.

Permeability data will be used to evaluate potential fate and transport mechanisms within the CDF. Permeability will be directly measured by the permeability test. Permeability can also be correlated with data reported from the triaxial shear strength test and loosely correlated with grain size data that will be collected.

Sampling methodology and analysis depth intervals are further defined in Section 2 of this SAP and within the FSP.

1.10 Data Quality Objectives and Criteria

This section presents a summary of the DQOs for each of the four discrete study elements of the sediment study described by this SAP, prepared consistently with USEPA guidance (USEPA 2006). Establishing DQOs for each study element provides an assurance that sampling will be focused on the goals of the RI/FS and will be sufficient to address those goals. The DQO summaries in the following subsections include, for each study element, a statement of the problem, a description of the analytical or interpretive approach to be followed, and components of the sampling design necessary to support the analytical or interpretive approach.

These DQOs will be addressed in the initial phase of sediment sampling, and the sediment sampling design to meet all of the goals is presented in Section 2. In addition to the study described in this sediment SAP, an Sediment Transport Modeling Memorandum will be developed and will define additional data needs for development of the physical CSM and the fate and transport analysis. The Sediment Transport Modeling Memorandum will be accompanied by an addendum to this sediment SAP, which will define additional sediment

parameters required for the sediment transport model, and the approach to collecting the required data. Depending on the results of these first phases of sediment sampling, additional sampling may subsequently be conducted to further support implementation of a selected remedial action.

1.10.1 DQOs for Study Element 1: Nature and Extent Evaluation

This RI/FS is being undertaken to address contamination of San Jacinto River sediments in the vicinity of the impoundments at the Site (Figure 5), and to plan for remedial actions. The spatial and vertical extent of remedial action is anticipated to be determined, at least in part, by exceedances of concentration-based PRGs for sediments.

1.10.1.1 Statement of the Problem

The primary problem to be addressed by Study Element 1, the nature and extent investigation, is uncertainty in the spatial and vertical extent of COPC contamination in sediments. Related problems to be addressed by Study Element 1 are: 1) current data are insufficient (in both spatial extent and types of measurements) to understand the movement of sediment-associated contamination into and away from the Site; and 2) chemical characteristics of Site and background sediments need to be clearly distinguished to evaluate the relative contribution of Site wastes outside the impoundment, and the dioxin and furan concentrations along the eastern perimeter of the original impoundments. The nature and extent evaluation, including characterization of upstream background sediment conditions, will address these problems and thereby facilitate the selection and implementation of remedial approaches.

A screening-level evaluation of the available chemical data (Section 1.6) indicates that the primary COPCs (dioxins and furans, and several metals) are present in the sediment at levels of potential concern to human and environmental health. Information on the concentrations of all of these chemicals throughout the Site will be needed to evaluate the horizontal and vertical extent of PRG exceedances. In addition, evaluation of the movement of Site-related contaminants within the river requires characterization of source materials in the impoundments (i.e., the source of contamination of Site sediments) using chemical signatures, and also characterization of sediments that are not influenced by the

impoundments. As described in Section 1.4.2, locations upstream in the San Jacinto River are relevant for assessing sediment conditions and sediment chemistry outside of the influence of the impoundment. Although some upstream data have been previously collected (Table 3), a larger number of samples is required for quantitative comparison, given the number of COPCs (Gonzales 2007). Finally, the available data contains few measurements for COPCs other than dioxins and furans, and additional upstream samples are required to characterize local background concentrations of these COPCs relative to conditions on the Site.

1.10.1.2 Analytical Approach

Study Element 1 includes three distinct types of data analysis:

- **Characterization of the spatial extent of contamination.** Sediment data will be integrated to provide an overall evaluation of the spatial and vertical extent of contamination using kriging to interpolate throughout the Site (Myers 1997). Depending on the results of the ecological and human health risk assessments, additional kriging may be carried out to evaluate the spatial extent of risk. Indexes of risk assessment results (e.g., locations with risk higher than specified thresholds) may be mapped to support the visualization and interpretation of risk assessment results.
- **Evaluation of the association of contaminants in sediments outside of the impoundments, but within the Site, with the contaminated materials within in the impoundments.** Patterns of dioxin and furan congeners within a sediment sample can vary considerably depending on the source (USEPA 2004b). Therefore, a pattern-matching approach will be used to evaluate both Site and upstream background samples to identify any pattern characteristic of the impoundment, and to determine the contribution of this pattern to other samples within the Study Area. The pattern-matching approach will provide an estimate of the fractional contribution of different mixing end members (i.e., source types) to each sample. Assuming that end members can be interpreted as sources, this analysis will therefore provide the basis for determining the fractional contribution of the impoundment to each sediment sample.
- **Comparison of Site sediment conditions with background sediments.** Evaluation of Site data relative to background conditions requires assessment of variability in

background conditions. For this analysis, a method analogous to a reference envelope approach will be used, in which an upper 95th percentile or upper tolerance limit will be derived to characterize background conditions. This approach provides a threshold value for comparing individual Site stations to background conditions.

1.10.1.3 Sample Collection Design

A design for sediment sampling which will result in the collection of additional data in a manner that that will meet the project goals, is discussed below.

1.10.1.3.1 On-site Chemical Distribution Samples

To characterize the nature and extent of impoundment-related contamination within the Site, sediment samples will be collected from a regular grid. Sample spacing will be based on the spatial gradient of dioxin/furan concentrations: within 1,000 to 1,500 feet (305 to 457 m) of the impoundment boundary and of the shoreline of the sand separation area on the Big Star Property; where concentration gradients appear to be steepest on the basis of existing data (Figure 13), surface samples will be collected on a 500-foot (152-m) grid. This grid extends to approximately 1,500 feet (457 m) from the impoundment to the east and south, where transport processes may redistribute sediments from the impoundment. At greater distances from the impoundment, samples will be collected on a 1,000-foot (305-m) grid (Figure 15). This design produces 40 sampling locations in the high-intensity area close to the impoundment, and an additional 19 locations throughout the Site, for a total of 59 Site sampling locations. In addition to the grid samples, surface sediment samples will be collected at four locations along the eastern perimeter of the impoundments, along the inside of the historical perimeter berm. These four locations correspond to the locations of four geotechnical borings in that same area (Study Element 4). At all of these locations, surface sediment will be collected to a depth appropriate for exposure characterization (0 to 4 inches; 0 to 10 cm) and analyzed for all primary COPCs. Physical parameters (sediment grain size, TOC, and solids) will also be analyzed in these samples.

There is a single sampling location at the center of the grid, at a central location within the impoundments. At this station, three surface samples will be collected to provide a reliable characterization of material within the impoundments. Coring will not be conducted within

the impoundment, because this area is expected to be reconstructed as a CDF for dredged material, and will not itself be dredged.

Cores for nature and extent characterization will be collected at a subset of 10 of the high-intensity sampling locations, focusing on locations closest to the impoundment (Figure 15). Cores will be collected using a gravity, slide-hammer, or vibratory coring device (depending on the conditions encountered in the field) to refusal or to a maximum depth of 10 feet (3 m), and sectioned at 1-foot (30-cm) intervals. Based on historical data collected within the site, TEQ concentrations for dioxins and furans (which are an indicator chemical group for the sediment study) reach a constant level at or before a depth of 10 feet (3 m) within the site. Primary COPCs, physical parameters, and geotechnical parameters (Atterberg limits and specific gravity) will be measured in the core samples.

Secondary COPCs will be measured in all surface sediment samples collected at coring locations and within the impoundment itself. At all other surface sampling locations, sufficient sediment will be collected and archived to allow subsequent analysis of secondary COPCs if warranted.

1.10.1.3.2 Background Samples

Upstream surface sediment will be collected to allow comparison of Site samples to local background conditions as part of the nature and extent investigation. Samples will be collected from transects across the river at several locations upstream of the Site. Transects will be located within the portion of the San Jacinto River below the channelized area because these conditions are likely to be more similar to sediments near the impoundment than samples farther upstream (Figure 16). Surface sediment will be sampled to a depth suitable for use in the exposure investigation (0 to 4 inches; 0 to 10 cm). A minimum of 20 total samples is necessary to accurately calculate an upper 95th percentile of the background data; the 11 background samples shown in Figure 16, in combination with the 13 existing upstream samples, will provide more than 20 data points. It is possible that some of these locations may be sufficiently different from Site samples in physical characteristics (i.e., grain size and OC content) that they should not be included in the local background dataset; therefore, this plan will produce 24 candidate background samples, rather than just

20. The layout of upstream samples will allow both lateral and longitudinal variations in upstream conditions to be evaluated.

1.10.2 DQOs for Study Element 2: Exposure Evaluation

The RI/FS will address risks to human and ecological receptors associated with contamination of San Jacinto River sediments at the Site (Figure 5). The exposure evaluation and risk assessment will support planning for remedial actions. This section presents the technical rationale and general approach for conducting the evaluation of human and ecological exposures to Site sediments.

1.10.2.1 Statement of the Problem

People visiting this portion of the San Jacinto River may be exposed to sediments via direct contact (ingestion and dermal) or indirectly through consumption of aquatic organisms (i.e., fish and shellfish) that have been exposed to the sediments. Available chemical data for Site sediment (TCEQ and USEPA 2006) indicate the presence of COPCs at concentrations greater than levels of potential concern to human health. Characterization of risk in support of selection and implementation of remedial approaches requires information on contamination in sediments accessible by people. One problem to be addressed by the sediment study is uncertainty regarding concentrations of COPCs present in sediments directly contacted by people visiting the Site.

A related problem is the potential for ecological receptors at the Site to be exposed through direct ingestion of contaminated sediment, and exposed to bioaccumulative chemicals through ingestion of prey organisms that have been exposed to contaminated sediment. The problem to be addressed in the ecological exposure evaluation is uncertainty regarding the magnitude and spatial extent of exposures of fish and aquatic-dependent wildlife receptors to contaminants in Site sediments.

For both human and ecological receptors, there is additional uncertainty regarding the exposures to COPCs in sediment in upstream background areas. Information on exposures and risks to human and ecological receptors both at the Site and in upstream background areas are needed in the evaluation of remedial options.

1.10.2.2 Analytical Approach

Study Element 2 will include the following types of analyses:

Characterization of exposures to human receptors using the Site.

- Within the Preliminary Site Perimeter, locations of probable human use are expected to occur along shoreline areas accessible by foot. The sediment zone of interest to the exposure evaluation is the intertidal sediments along the shoreline (i.e., those extending from the high tide elevation to the low tide elevation). Within this sediment zone, three human use areas have been designated for collection of additional data; at each one of these, ten distinct locations will be sampled. These human use areas are:
 - The eastern shoreline of the sand separation area on the Big Star Property
 - The shoreline on both sides of the channel under the I-10 Bridge over the San Jacinto River
 - The shoreline to the west of the shipping berth on the Big Star Property
- Sediment will be sampled at each of the ten stations in each of the human use areas, at two sediment depths: 0 to 6 inches (0 to 15 cm) and 6 to 12 inches (15 to 30 cm). Five surface sediment samples from each of the exposure areas and the corresponding subsurface sediment samples from the eastern shoreline of the Big Star Property will be analyzed initially for primary COPCs. The remaining five surface samples from each area, five subsurface samples from the eastern shoreline of the Big Star Property, and all ten subsurface samples from the other two exposure areas will be archived.
- Surface samples will be evaluated using the following steps:
 - The mean COPC concentration within each exposure area will be compared with the means from the other exposure areas. Data will be pooled across those exposure areas that are not statistically significantly different.
 - The 95 percent upper confidence limit (UCL) on the mean concentration of each COPC will be calculated for each dataset, which may consist of five samples or may be larger if some datasets were pooled. The 95 percent UCL will be used as an estimate of the reasonable maximum exposure (RME) concentration for direct contact of people with intertidal sediments (USEPA 1992). If the 95 percent UCL

is greater than the maximum, it will be concluded that there is significant variation in the dataset and additional information is required. In these cases, the additional five samples from the appropriate human use area will be analyzed, and used to calculate the final RME. If the 95 percent UCL is less than the maximum, it will be concluded that the existing data are sufficient to characterize the central tendency and RME exposures, and the archived samples will not be analyzed.

- The decision whether to analyze the subsurface samples from under the I-10 Bridge and west of the shipping berth on Big Star will be made based on the results of the surface samples from these areas. If the 95 percent UCL for the surface sediment exceeds the soil PRG, the subsurface sediment samples will be analyzed. Initially, five samples will be analyzed using the same scheme described above. If the 95 percent UCL for the surface sediment does not exceed the soil PRG, it will be concluded that exposures in that area are not significant and that additional information is not needed to evaluate that area.
- For the BHHRA, exposure point concentrations for sediment in each human use exposure area will be calculated as using the statistically appropriate measure of the central tendency and the 95 percent UCL to represent the RME.

Characterization of exposures to ecological receptors on the Site.

- Results of the sediment sampling will be used to evaluate exposures of fish and aquatic-dependent wildlife receptors to contaminants in intertidal sediments. For evaluation of exposures to fish and aquatic-dependent wildlife, sediments in three wildlife use areas within the Preliminary Site Perimeter will be collected and analyzed. These wildlife use areas are:
 - The shoreline between the impoundments and the sand separation area on the Big Star Property
 - The shoreline of the island that is north of the impoundments
 - The shoreline along the islands to the south of the I-10 Bridge over San Jacinto River, on the east side of the main channel
- Concentrations of COPCs in intertidal sediments from these areas will be used to characterize the exposure profiles in each area for each bird and mammal receptor, and for nearshore-dwelling fishes. The exposure profile will consist of a measure of the central tendency concentration, and a measure of the RME concentration, but the

statistics to be used for these (e.g., the mean vs. the median for the central tendency) will be determined after the chemistry data have been evaluated to identify the most appropriate representation for these areas.

- For evaluation of exposure of benthic macroinvertebrates to primary COPCs, the measured concentrations at sampling stations throughout the Site will be used. Sediment chemistry data for the shoreline stations described above, and for samples collected for Study Element 1, will be used in this exposure evaluation.
- Sediment chemistry data will also be used in an evaluation of bioaccumulation of chemicals at the Site. This aspect of the exposure evaluation will use the results of sediment chemistry from the ecological exposure areas described above, and the sediment chemistry results from Study Element 1. This analysis will involve statistical evaluations for correlations between sediment chemical concentrations with concentrations in benthic macroinvertebrate and fish tissues that will be collected as part of the Tissue SAP. If a predictive relationship is found, it may be used as one method of developing site-specific risk-based sediment PRGs.

Comparison of exposures of human and ecological receptors to Site sediment contaminants with those of background.

- Exposures to sediment contaminants on the Site will be compared with exposures at background locations, to determine the extent to which Site sediments pose an excess risk to humans, fish, and aquatic-dependent wildlife (i.e., a risk above that which would be experienced in the absence of Site contamination). To allow comparison of exposures to COPCs in Site sediments to those in upstream background areas, locations outside the Site boundary and upstream will be sampled. For the human health risk assessment, ten stations will be sampled upstream. Five of the surface sediment samples will be analyzed initially for primary COPCs. The remaining five surface sediment samples and all of the subsurface samples will be archived for possible future analysis. For the ecological exposure assessment, three additional samples of sediment from a shoreline upstream will be collected and analyzed for primary COPCs with additional sediment archived for possible future analysis if needed for the ecological exposure evaluation. The specific means of comparisons of Site risks with background risks will be based on the risk assessment results. Direct statistical comparisons of sediment chemistry between sediments in Site and background exposure areas may also be conducted. The specific statistical tests to be

used will depend on the characteristics of the data.

1.10.2.3 *Sample Collection Design*

Data quality specifications, including analytical concentration goals, laboratory analytical methods, the number and type of field and laboratory QC samples, and the methods for evaluating and characterizing data quality, are specified in Section 2.5 of this document.

The sampling plan for the human health evaluation calls for ten sampling stations in each of the three potential Site exposure areas that are listed above and shown in Figure 17. These exposure areas were selected because they are observed or likely locations where people go to fish and can contact sediments while doing so, and because they are locations that are or may have been impacted by releases from the Site. The ten sampling stations identified in the upstream background area are shown on Figure 16. In each of these four exposure areas, ten surface (0 to 6 inches; 0 to 15 cm) and ten subsurface (6 to 12 inches; 15 to 30 cm) sediment samples will be collected. Sampling stations will be located between the high tide mark and the low tide mark.

To evaluate ecological exposures, surface sediment samples (0 to 4 inches; 0 to 10 cm) will be collected from shallow water in three on-site locations and in one background location where foraging wildlife are expected to come into contact with sediment (Figure 17). At each of these general locations, three separate samples will be collected. This design allows determination of whether risks to aquatic-dependent wildlife are uniform or variable within the Site, and allows evaluation of exposures on the Site relative to background conditions.

1.10.3 *DQOs for Study Element 3: Physical CSM and Fate and Transport Evaluation*

The RI/FS will provide information to characterize the potential movement of sediment-associated contaminants in the vicinity of the Site (Figure 5). This information is necessary to plan for remedial actions.

1.10.3.1 Statement of the Problem

Information to support the evaluation of chemical fate and transport processes is needed to inform the evaluation of remedial alternatives. Understanding both qualitatively and quantitatively how sediment associated chemicals move into, within, and away from the Site and the Study Area is required for evaluation of the extent of potential impacts of materials deposited in the impoundments, the feasibility of various remedial actions, and the current and likely future sediment conditions within the Site.

The main goal of Study Element 3 is to determine the primary physical and chemical processes that are controlling chemical fate and transport within the Study Area. After the primary controlling processes are identified, this information will be used to design methods (e.g., computer modeling) to quantitatively analyze and evaluate chemical fate and transport within the Site and Study Area. The ultimate goal of the quantitative analyses performed for Study Element 3 of the RI/FS will be to determine the efficacy of various remedial alternatives.

The immediate information needs to be addressed by Study Element 3 of the sediment study are the spatial distribution of bed types and COPC concentrations and bed sediment properties, including TOC data. The Sediment Transport Modeling Memorandum and associated SAP Addendum (Section 1.8) will address additional DQOs for this Study Element.

1.10.3.2 Analytical Approach

For the chemical fate and transport evaluation, the upstream boundary of the Study Area is located about 4 miles (6 kilometers) upstream of the Site, and the downstream area of interest extends to the downstream boundary of the Study Area (Figure 5). Analyses of the data generated for Study Element 3 by the study described in this sediment SAP will allow a qualitative description of the spatial distribution of bed types (i.e., cohesive and non-cohesive bed areas); spatial distribution of grain size distribution; net sedimentation rates; and incoming sediment load from the river.

1.10.3.3 *Sample Collection Design*

For this phase of the sediment transport analysis, the data collected as part of the nature and extent investigation (Study Element 1) will be used. The sampling design for that Study Element is described in Section 1.9.1.

1.10.4 *DQOs for Study Element 4: Engineering Construction Evaluation*

The RI/FS will address the nature and extent of contamination and associated risks in the vicinity of the Site (Figure 5), and will result in plans for remedial actions. Additional information is needed to evaluate the feasibility of construction of a CDF within the area of the impoundments.

1.10.4.1 *Statement of the Problem*

The former impoundment containment berms have been degraded through regional subsidence, adjacent work activities, and erosional energy from the San Jacinto River. The impoundment containment needs to be re-established. By rebuilding the containment berms, an opportunity will be created for replacement of sediments within the impoundment footprint that may have been resuspended and redistributed outside of the impoundment footprint and within the river channel. Geotechnical data are required to evaluate CDF and containment design and construction elements. Evaluations include dredgability of the river sediments, berm design, and CDF design. Geotechnical information required includes conventional parameters, sediment permeability, sediment strength, and sediment compressibility.

The goals of the engineering and construction evaluation are to obtain sufficient data to allow conceptual containment and capping structure designs to be prepared. The data collection and evaluation will support feasibility, conceptual, and final design studies for the impoundment area.

1.10.4.2 *Analytical Approach*

The analytic approach will use the geotechnical data collected during the field and laboratory program to develop a range of expected permeability, strength, and

compressibility characteristics for the variety of geologic horizons that are encountered beneath the Site. Direct measurements of permeability, strength, and compressibility as measured in the lab will be compared to correlated parameters from the conventional geotechnical test results.

Results of geotechnical evaluations can be highly dependent on input parameter assumptions. For berm stability, bearing capacity, and settlement evaluations, a range of strength and compressibility parameters will be considered during conceptual design based on the results of the field investigation. Stability will be modeled using limit-equilibrium methods and if appropriate, Monte-Carlo type simulations will be performed to assess the sensitivity of the results to the input assumptions. Bearing capacity and settlement will be computed using spreadsheet implementations of standard-of-practice geotechnical equations.

1.10.4.3 *Sample Collection Design*

There are no specific acceptance criteria for geotechnical sampling that are independent from the acceptance criteria used for nature and extent sampling. The samples to be collected in support of Study Element 4 include sediment borings and sediment grabs for vane shear tests (VSTs), and are illustrated on Figure 14. Sediment borings will be collected at nine locations for measurements of sediment strength and stability and will be used to support engineering design for a CDF. VSTs will be performed at six locations in the impoundment and in locations around the berm. Details of the sample collection design are presented in Section 2 of this SAP, with field procedures specified in the accompanying FSP.

1.10.5 *Integration of Study Element Designs*

The differing goals of the four study elements leads to differences in the type and locations of samples collected, and of the measurements made on those samples. However, there are also commonalities among the requirements of the different study elements that allow some samples to be used for multiple purposes. The overall sampling design can take advantage of these commonalities as follows:

- Surface sediment samples collected for the nature and extent investigation from both the Site and upstream background areas will also provide exposure estimates for aquatic ecological receptors.

- Surface sediment and core samples collected for the nature and extent investigation will also provide information on bed type, COPC concentrations, and bed properties for the fate and transport investigation.
- Splits of selected core samples will provide information for the geotechnical investigation.

1.11 Special Training and Certification

A technical team will be assembled with the requisite experience and technical skills to successfully complete the 2010 sediment study. All technical team personnel involved in sample collection will have extensive environmental sampling experience.

Sampling personnel who enter the exclusion zone and contaminant reduction zone (see Attachment A1, Sections 5.1.1 and 5.1.2 for definition and discussion of these zones) may be required to have completed the 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) standard training course and 8-hour refresher courses (see overall HASP [Anchor QEA 2009] for further explanation). The training provides employees with knowledge and skills that enable them to perform their jobs safely and with minimum risk to their personal health. Documentation of course completion will be maintained in personnel files.

Selected laboratories will hold certification through the National Environmental Laboratory Accreditation Program for the methods which that laboratory will perform, where applicable. Training and certification requirements for laboratory personnel will be provided in the laboratory QA plans (to be submitted under separate cover).

1.12 Documents and Records

Records will be maintained documenting all activities and data related to sample collection and to laboratory analyses. Results of data verification and validation activities will also be documented. Procedures for documentation of these activities are described in this section.

The QAPP, FSP (Appendix A), and the HASP Addendum 1 for this sediment study (Attachment A1) will be provided to every task participant listed in Section 1.1. Any

revisions or amendments to any of the documents that make up the FSP will also be provided to these individuals.

1.12.1 Field Records

Components of field documentation are discussed in Section 3 of the FSP. Integral and Anchor QEA's field leads will ensure that the field team receives the final, approved version of the QAPP (including the FSP and sediment HASP [Attachment A1]) prior to the initiation of field activities. Field records that will be maintained include the following:

- Field logbooks
- Photo documentation
- Field data and sample collection information forms
- Field change request forms (as needed)
- Sample tracking/chain-of-custody (COC) forms

Observations recorded in the field logbook will be used to provide context and aid in presentation and interpretation of analytical results. Additional details regarding the content and use of these documents are described in Section 3.1 of the FSP.

1.12.2 Laboratory Data Reports

All activities and results related to sample analysis will be documented at each laboratory. Internal laboratory documentation procedures are described in the laboratory QA manuals (to be submitted under separate cover).

Each laboratory will provide a data package for each sample delivery group or analysis batch that is comparable in content to a full CLP package. The format of the data may differ from CLP requirements. Each data package will contain all information required for a complete QA review, including the following:

- A cover letter discussing analytical procedures and any difficulties that were encountered
- A case narrative referencing or describing the procedures used and discussing any analytical problems and deviations from SOPs and this QAPP

- COCs and cooler receipt forms
- A summary of analyte concentrations (to two significant figures, unless otherwise justified), method reporting limits (MRLs), and method detection limits (MDLs) or estimated detection limits (EDLs)
- Laboratory data qualifier codes appended to analyte concentrations, as appropriate, and a summary of code definitions
- Sample preparation, digestion, extraction, dilution, and cleanup logs
- Instrument tuning data
- Initial and continuing calibration data, including instrument printouts and quantification summaries, for all analytes
- Results for method and calibration blanks
- Results for all QA/QC checks, including but not limited to labeled compounds, surrogate spikes, internal standards, serial dilutions, laboratory control samples, matrix spike samples, matrix spike duplicate samples, and laboratory duplicate or triplicate samples provided on summary forms
- Instrument data quantification reports for all analyses and samples
- Copies of all laboratory worksheets and standards preparation logs

Data will be delivered by the laboratories in both hard copy and electronic format to the task QA coordinator, who will be responsible for oversight of data verification and validation and for archiving the final data and data quality reports in the project file. Electronic data deliverables (EDDs) will be compatible with the project database.

1.12.3 Data Quality Documentation

Data verification (i.e., confirming the accuracy and completeness of field and laboratory data) will be completed by the SJRWP technical team for data generated in the field, and by each laboratory for the data that it generates. Data validation reports for chemical analyses will be prepared as described in Section 4 and provided to the task QA coordinator. All changes to data stored in the database will be recorded in the database change log. Any data tables prepared from the database for data users will include all qualifiers that were applied by the laboratory and during data validation.

1.12.4 Reports and Deliverables

The laboratories will keep the Laboratory QA Coordinator apprised of their progress on a weekly basis. The laboratories will provide the following information:

- Inventory and status of samples held at the laboratory in spreadsheet format by sample delivery group
- Summaries of out-of-control laboratory QC data and any corrective actions implemented
- Descriptions and justification for any significant changes in methodology or QA/QC procedures

Once all field programs for the Site are complete, a draft Preliminary Site Characterization Report (PSCR) will be prepared and submitted to USEPA. The draft PSCR will contain sample location maps, validated analytical chemistry results, and information on the extent of contaminant migration through the sediment pathway. Consistent with the 2009 UAO, the draft PSCR will be submitted to USEPA within 30 days after the completion of all laboratory and data validation work for all of the field studies that will be required for the RI/FS (a schedule will be provided in the RI/FS Work Plan). Prior to submittal of the draft PSCR, data will be made available online within 30 days of receipt of final validated results. Interpretation of the data will be presented in the RI report.

2 DATA GENERATION AND ACQUISITION

2.1 Sampling Design

The sediment sampling design for the RI/FS incorporates a number of different components. The individual study components (as discussed in the QAPP) differ in the locations, depths, and analytes to be measured in the sediment. The sampling design can be summarized as follows:

- Surface sediment sampling and analysis of primary COPCs at 29 locations in and near the impoundments (Figure 15) on a 500-foot (152-m) grid, and at four locations along the eastern perimeter of the original impoundments. Secondary COPCs will be measured at an additional 11 locations on the 500-foot (152-m) grid. Additional sediment from the 29 locations will be archived for later analysis of secondary COPCs, if necessary. These samples will provide data for the nature and extent, exposure, and fate and transport analyses. Data from locations from within the impoundment area (five stations), will allow characterization of waste materials.
- Surface sediment sampling and analysis of primary COPCs at an additional 19 locations within the Site boundary (Figure 15), on a 1,000-foot (305-m) grid. These samples will provide data for the nature and extent, exposure, and fate and transport analyses. Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs.
- Collection of cores and analysis of primary COPCs at 10 locations within approximately 1,000 feet (305 m) of the impoundment (Figure 15). Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs. These samples will provide data for the nature and extent evaluation and for dredgability assessments.
- Collection of surface samples and analysis of primary and secondary COPCs at 11 locations upstream of the Site but downstream of the channelized portion of the San Jacinto River (Figure 16), to allow estimation of local background conditions for the nature and extent, exposure assessments, and fate and transport analysis.
- Collection of intertidal sediment samples at 30 locations in three different human exposure areas on three beaches (Figure 17) within the Site to evaluate potential human exposure and whether the beaches represent different exposure conditions for human receptors. Surface and subsurface sediment samples will be collected at all 30

stations at each of the three beaches. Half of the surface intertidal sediment samples will be analyzed for primary COPCs, with additional sediment archived for possible future analysis of secondary COPCs. Surface sediment samples from the other half of these stations will be archived for future analysis of primary and/or secondary COPCs, if necessary (Section 1.10.2.2).

- In addition, half of the subsurface samples collected at Stations SJSH011 through SJSH020 will initially be analyzed for primary COPCs; the archived subsurface sediment samples from the other half of these stations and all of the subsurface samples from the other two beaches will be archived for possible future analysis of primary and/or secondary COPCs, if necessary (Section 1.10.2.2).
- Collection of intertidal sediment samples for analysis of primary COPCs at ten locations upstream of the Site, but downstream of the channelized portion of the San Jacinto River (Figure 16), for evaluation of human exposures under upstream background conditions. Surface and subsurface sediment samples will be collected at all 10 stations at this beach. Half of the surface intertidal sediment samples will be analyzed for primary COPCs. The other half of the surface and all of the subsurface samples will be archived for possible future analysis of primary and/or secondary COPCs, if necessary (Section 1.10.2.2).
- Collection of intertidal samples from nine locations at three ecological exposure areas on the Site (Figure 17) and three locations at one ecological exposure area upstream (Figure 16) for characterization of exposure of ecological receptors such as wading birds. These samples will be analyzed for primary COPCs. Additional sediment from these stations will be archived for possible future analyses of secondary COPCs, if necessary.
- Sediment borings at nine locations and VSTs at six locations in the impoundment and in locations around the perimeter berms (Figure 14). Measurements of sediment engineering characteristics (strength and settlement behavior) will be used to support engineering design for a CDF.

The planned locations of these samples are shown in Figures 14, 15, and 16. Some of the samples to be collected will be used for multiple elements of the overall study. Table 13 summarizes the suite of samples to be collected under this SAP in terms of placement, depth, analytes, and study element. One surface sediment sample will be collected at each location

sampled for the nature and extent evaluation, except for the location in the impoundment area: in this location, a field triplicate (i.e., three unique samples placed approximately 10 m [33 feet] apart) will be collected to assure an accurate characterization of the chemical characteristics (e.g., dioxin and furan “fingerprints”) of the waste material within the impoundments. In general, surface sediment samples collected for the nature and extent evaluation will also be used to support the evaluations of exposure of aquatic receptors, sediment fate and transport, and sediment dredgability. Samples collected to support exposure assessments for humans and wildlife, and to support CDF design, are more specialized in purpose and location, and will be collected in nearshore, shallow areas.

2.2 Sampling Methods

Sampling methods that will be used to collect the suite of samples summarized in Section 2.1 are presented in the following sections. Sampling methods are described in detail in the FSP.

2.2.1 Surface Sediment Samples for Chemical Analyses

Two different kinds of surface sediment grab samples will be collected during the 2010 sediment study to address Study Elements 1 and 2:

- Intertidal sediments for exposure assessment
- Submerged San Jacinto River sediments

The intertidal sediment samples will be collected at two different depths. Surface sediment samples (4 inches; 10 cm) for characterization of nature and extent and for exposure of ecological receptors, and surface sediment samples (6 inches; 15 cm) for characterization of human health exposure will be collected. Sampling equipment may include stainless-steel spades or shovels, a stainless-steel hand corer, or a modified petite-Ponar grab sampler, depending on the conditions encountered in the field. One surface sediment sample will be collected at each location sampled for the nature and extent evaluation, except for the location in the impoundment area (Station SJNE022); in this location, a field triplicate will be collected to assure an accurate characterization of waste material present. Sediment from the field triplicates at Station SJNE022 will be processed as three separate and distinct samples. At all other chemical analysis stations, the sediment collected at each station will be placed into a decontaminated stainless-steel bowl and homogenized using a stainless-steel spoon

until the sediment attains a visually uniform color and texture. Sediment subsamples will then be removed for the various kinds of laboratory analyses and for archiving.

Submerged San Jacinto River sediments may be collected with a power grab, or a van Veen grab sampler (or equivalent type of equipment) in accordance with standard methods used by USEPA (1997b). Sample collection and processing will follow the same methodology described above.

Further details of the surface sediment sampling methods, collection, and sample processing can be found in the FSP. Locations of surface sediment sampling stations are shown in Figures 14, 15, 16, and 17.

2.2.2 *Subsurface Sediment Samples for Chemical Analyses*

Two different kinds of subsurface sediment will be collected during the 2010 sediment study:

- Intertidal sediments for exposure assessment
- Submerged San Jacinto River sediments

The subsurface intertidal sediments will be collected from 6 to 12 inches (15 to 30 cm) with a stainless-steel hand corer. Submerged San Jacinto River sediment core samples will be collected at 1-foot [30-cm] intervals to refusal or to a maximum depth of 10 feet with a gravity, slide-hammer, or vibratory coring device (depending on the conditions encountered in the field) in accordance with standard methods used by USEPA (1997b). Each core sample will be inspected for physical characteristics and described on a core profile form (see Attachment A3 of the FSP). Cores designated for chemical analysis will be sectioned into 1-foot (30-cm) intervals. The sediment from each core section will be homogenized with a decontaminated stainless-steel spoon until the sediment attains a visually uniform color and texture. Sediment touching the sides of the core tube will be excluded from each sample. Sediment subsamples will then be removed for the various kinds of laboratory analyses and for archiving. A minimum of one core will be collected at each nature and extent core station, and a minimum of three cores will be collected at each beach that is considered a human exposure area.

Further details of the subsurface sediment sampling methods, collection, and sample processing can be found in the FSP.

Locations of subsurface sediment sampling stations are shown in Figures 15 and 17. Where both cores and surface sediment samples are to be collected at the same station, the surface sediment sample will be adjacent to the core, and all core intervals will be a full 1 foot (30 cm) deep.

2.2.3 *Sediment Geotechnical Borings*

Subsurface sediment will be collected by advancing borings at selected locations to obtain geotechnical data.

Locations of geotechnical borings are shown in Figure 14. The proposed sampling intervals and test parameters for borings in the CDF area are identified in Table 14. The subsequent sections provide details regarding sample collection methods, processing methods, and the sampling design plan.

2.2.3.1 *Upland and In-Water Boring Methods*

Sediment samples will be collected using upland and in-water boring methods consistent with American Society for Testing and Materials (ASTM) procedures (ASTM D 1452). The upland locations will use a track-mounted or similar limited access drill rig. The over water boring locations will be advanced from a barge-mounted drill rig. Following completion of each boring within the impoundment, the drill equipment will be decontaminated on a designated pad located within the confines of the impoundments using a hot water pressure wash.

Depending on the drill method used, the sampler will be advanced through a series of hollow stem augers, or through a steel casing. In either case, the drilling activity (drill fluid, cuttings, and sample collection) will be effectively separated from the surrounding water to minimize the potential for water quality impacts associated with the drilling. Uplands drilling will be performed within a contained enclosure such that cuttings and drill fluid will not be spread beyond the immediate boring hole, and will not enter surface water.

All cuttings generated by the drilling operation will be placed into 55 gallon drums or similar approved disposal bin. Sealed drums will be transported off site for disposal at an approved facility.

Further details of the boring methods, collection, processing, and sampling can be found in the FSP.

2.2.3.2 *Split-Spoon and Thin-Walled Tube Processing Methods*

Split spoon samples will be logged and processed on site by the field geologist. Prior to processing, a visual description of each sample will be recorded on a standard boring log (Attachment A3 of the FSP). The following parameters will be noted:

- Sample recovery
- Physical sediment description in accordance with the Unified Soil Classification System (includes sediment type, density/consistency of sediment, color)
- Odor (e.g., hydrogen sulfide, petroleum)
- Visual stratification, structure, and texture
- Vegetation
- Debris (e.g., woodchips or fibers, paint chips, concrete, sand blast grit, metal debris)
- Evidence of biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen

Discrete samples will be taken out of the split spoon directly from the selected depth interval and placed into laboratory-supplied jars. Sample jars will be stored in a cooler out of direct sunlight until transportation to the testing lab. A COC form will be logged by the processing staff and relinquished to the courier and then to the testing lab staff.

Thin-walled tube samples (e.g., Shelby tubes) do not allow direct observation of the sample material. When removed from the boring, length of recovery will be measured and recorded prior to cleaning up the tube. Once the tube is clean, both the top and bottom will be sealed and the sample will be stored in a vertical position in the same alignment it was removed.

2.2.3.3 *Boring Design Plan*

Locations for the borings are illustrated on Figure 14. Final boring locations and sampling intervals may vary depending on site access issues and based on determinations made by the field geologist. Borings will be drilled to varying depths depending on the proposed location of the berm and other components of the CDF. Two 120-foot (37-m) deep borings and five 60-foot (18-m) deep borings will be drilled in the vicinity of the berm. Within the proposed limits of the CDF, two 30-foot (9-m) deep borings will be advanced to evaluate the thickness of the waste material. Geotechnical testing will include grain size, Atterberg limits, moisture content, specific gravity, permeability, CU triax compression, and one-dimensional consolidation testing.

2.2.4 *Vane Shear Testing*

VSTs will be performed at six locations and at up to three depths for each location in selected areas of the CDF footprint, which will generally coincide with the historic berm locations (Figure 14) and within the interior of the impoundment. Table 15 summarizes the depths and details of the VST testing. The grab samples will be photographed, logged, and placed into 16-ounce jars for physical testing. Additional VST sampling details can be found in the FSP.

2.3 *Sample Handling and Custody*

Principal documents used to identify samples and to document sample possession will be field logbooks and COC records. Custody will be documented for all samples at all stages of the analytical or transfer process. COC procedures for sample handling prior to delivery to each laboratory are outlined in Section 3.5 of the FSP.

Upon receipt of samples at each laboratory, the physical integrity of the containers and seals will be checked, and the samples will be inventoried by comparing sample labels to those on the COC forms. Each laboratory will include the COC and shipping container receipt forms in the data package. Any breaks in the COC or non-conformances will be noted and reported in writing to the project laboratory coordinator within 24 hours of receipt of the samples. Each laboratory QA plan (to be provided under separate cover) includes procedures

used for accepting custody of samples and documenting samples at the laboratory. The laboratory project manager will ensure that a sample-tracking record is maintained that follows each sample through all stages of sample processing at the laboratory.

Samples will be stored in accordance with Table 16. Samples for chemical analyses will be stored under refrigeration ($4 \pm 2^{\circ}\text{C}$). Aliquots of the samples submitted to the analytical laboratory for archiving for future analysis will be stored at -20°C . Each laboratory will maintain COC documentation and documentation of proper storage conditions for the entire time that the samples are in its possession.

The laboratories will not dispose of the samples for this task until authorized to do so by the task QA coordinator. After authorization is obtained, each laboratory will dispose of samples, as appropriate, based on matrix, analytical results, and information received from the client.

2.4 Laboratory and Analytical Methods

Sediment samples collected for this study will be analyzed for a variety of chemical and physical parameters as outlined in Table 17. The proposed laboratory methods are described below and are summarized in Table 17. These methods are consistent with requirements provided in SW-846 (USEPA 2008b), ASTM (2009), and other established and widely accepted protocols. Analyte lists are provided in Table 18. Expected MRLs and MDLs will be provided following laboratory selection.

2.4.1 Physical Properties and Geotechnical Analyses

All sediment samples for nature and extent evaluation will be analyzed for percent moisture, TOC, grain size, Atterberg limits, and specific gravity. In addition, some sediment samples from the geotechnical borings will be analyzed for percent moisture, grain size, Atterberg limits, and specific gravity. Sediment samples collected for exposure assessment will be analyzed for percent moisture, TOC, and grain size.

Percent moisture for samples for nature and extent evaluation and exposure assessment will be determined according to USEPA method 160.3, which is a method commonly used by

chemistry laboratories to determine total solids. These results will be used to calculate analyte concentrations on a dry-weight basis and will also be reported in the database. Sediment moisture content for geotechnical samples will be determined according to ASTM method D-2216. These results will be used in tandem with the Specific Gravity results to compute *in situ* void ratio, which is directly related to dry and buoyant unit weight (i.e., “density”) of sediments.

TOC in sediment will be analyzed by USEPA method 9060, modified for sediment. Samples will be pretreated with hydrochloric acid to remove inorganic carbon, dried at 70° C, and analyzed by combustion in an induction furnace. Quadruplicate TOC analyses, as specified in the method, will not be required for this project. Instead, laboratory duplicate analyses will be performed at a frequency of 5 percent, one duplicate analysis per 20 samples.

Grain size distribution will be determined according to ASTM methods D-422 and D-1140, with modifications described in USEPA (1986). Organic material in the samples will not be oxidized prior to analysis.

Atterberg limits and specific gravity will be determined using applicable ASTM methods (Table 12).

2.4.2 Sediment Chemistry

All sediments sampled for nature and extent and exposure evaluations will be analyzed for the primary COPCs (Table 8). A subset of these sediments will be analyzed for the secondary COPCs. The list of analytes that will be reported for each of these samples is provided in Table 18. Sediment analyzed for metals other than mercury will be digested with strong acid per USEPA method 3050 and analyzed by inductively coupled plasma-atomic emission spectrometry per USEPA method 6010B, or by inductively coupled plasma/mass spectrometry per USEPA method 6020.

USEPA method 7471A (USEPA 2008b) will be used for mercury analyses. Samples will be extracted with aqua regia and oxidized using potassium permanganate. Analysis will be completed by cold vapor atomic absorption spectrometry.

Dioxins and furans in sediment samples will be extracted and analyzed in accordance with either USEPA method 1613B or USEPA method 8290A (USEPA 1994, 2008b). All extracts will undergo silica gel cleanup. Additional cleanup procedures will be used as necessary. Samples will be analyzed by high-resolution gas chromatography with high-resolution mass spectrometry (HRGC/HRMS). Detection limits are calculated on an individual compound and sample basis and depend on the signal-to-background ratio for the specific labeled isomer.

SVOCs will be extracted using soxhlet or pressurized fluid extraction procedures, processed through gel permeation chromatography (USEPA method 3640A), and analyzed by gas chromatography/mass spectrometry in accordance with USEPA method 8270C (USEPA 2008b). Tentatively identified compounds will not be reported. For analysis of sediment, sample modifications such as use of selected ion monitoring or large volume injectors may be made to these methods to improve MRLs.

VOCs will be analyzed by purge and trap extraction and GC/MS in accordance with USEPA method 8260B (USEPA 2008b). Tentatively identified compounds will not be reported.

2.4.3 Sediment Permeability

Permeability will be measured in the lab to evaluate the sediment's ability to allow water to pass through. Permeability in the lab will be measured either by the constant head test for coarse-grained samples (ASTM D 2434) or the falling head test for fine-grained samples (ASTM D 5084). Multiple permeability tests will be performed on samples of the waste material encountered within the CDF footprint.

Fine-grained samples for these tests will be obtained by taking undisturbed samples from the borings using thin-walled tubes. Special care will be taken, as noted in the FSP, when handling and transporting the thin-walled tubes so as to minimize potential sample disturbance.

2.4.4 *Sediment Consolidation*

Consolidation testing will be performed to determine the sediment's settlement behavior over time. Consolidation testing can also provide rough measurements of permeability. Consolidation in the lab will be measured for very soft to stiff fine-grained sediments by the one-dimensional consolidation test (ASTM D 2435). Multiple consolidation tests will be performed to evaluate potential subsurface variability across the Site.

Fine-grained samples for these tests will be obtained by collecting undisturbed samples from the borings using thin-walled tubes. Special care will be taken, as noted in the FSP, when handling and transporting the thin-walled tubes so as to minimize potential sample disturbance.

2.4.5 *Consolidated-Undrained Triaxial Sediment Strength Test*

CU triax testing will be conducted in the lab on undisturbed samples sediment obtained via use of a thin-walled tube (e.g., Shelby tube). This test measures the sediment's strength through a variety of loading and confining pressures (ASTM D 4767). The test measures pore pressures in the sediment to allow both total and effective stresses sediment parameters to be reported. The Technical Team Coordinator will work directly with the testing lab to determine the range of confining pressures at which the tests will be run. These confining pressures will be based on the depth from which the sample was collected, and considering the future anticipated loads from the CDF. Multiple CU triax tests will be performed to evaluate potential subsurface variability across the Site.

Fine-grained samples for these tests will be obtained by taking undisturbed samples from the hollow-stem auger explorations using thin-walled tubes. Special care will be taken, as noted in the FSP, when handling and transporting the thin-walled tubes so as to minimize potential sample disturbance.

2.5 *Quality Control*

QC samples will be prepared in the field and at each laboratory to monitor the bias and precision of the sample collection and analysis procedures.

2.5.1 *Field Quality Control*

Field QC samples for this study will include field split samples (homogenization duplicate), field triplicate (three unique samples at the same location), equipment filter wipes, filter blanks, and Standard Reference Material (SRM). Because field QC sampling is not standard protocol for geotechnical engineering investigations, field QC samples will not be collected for Study Element 4.

Field split samples will be collected at a frequency of one for every 20 field samples processed. A field triplicate will be collected at one station in the impoundment area. Equipment filter wipes will consist of clean, ashless filter papers supplied by the analytical laboratory. Equipment filter wipes will be collected at a frequency of one for every 20 field samples processed for each type of nondedicated equipment in direct contact with the sediments being collected. One filter blank will be collected for each lot of filter wipes used during the field effort. Where available, SRMs for sediments will be submitted from the field at a frequency of once per sampling event.

Procedures for preparing field split samples, equipment wipes, and SRMs are presented in Section 2.3 of the FSP. Validation criteria and procedures for field QC samples are described in Sections 4.1 and 4.2 of this QAPP.

2.5.2 *Laboratory Quality Control*

Extensive and detailed requirements for laboratory QC procedures are provided in the methods that will be used for this investigation (Table 17). QC requirements include control limits and requirements for corrective action in many cases. QC procedures will be completed by each laboratory, as required by each protocol and as indicated in this QAPP. Laboratory QC procedures are addressed for chemical and physical laboratories below.

The overall quality objective for this task is to develop and implement procedures that will ensure the collection of representative data of known and acceptable quality. The QA procedures and measurements that will be used for this project are based on USEPA guidance (USEPA 2002b, 2008b, 1986) and on established laboratory methods from other sources (APHA 1998; ASTM 2009).

Laboratory QC procedures for geotechnical testing are defined in the relevant ASTM standard for each test. Table 12 provides the ASTM standard methods that will be applied to each test. Further detail on laboratory QC procedures per ASTM can be found within the language of the standard. The geotechnical laboratory will follow general QC procedures for personnel qualifications, quality systems, equipment calibration, and records retention as described in ASTM D 3740.

2.5.2.1 *Chemistry Laboratory QA*

The frequency of analysis for laboratory control samples, matrix spike samples, matrix spike duplicates or laboratory duplicates, and method blanks will be one for every 20 samples or one per extraction batch, whichever is more frequent. Surrogate spikes, labeled compounds, and internal standards will be added to every field sample and QC sample, as required. Calibration procedures will be completed at the frequency specified in each method description. Performance-based control limits have been established by each laboratory. These and all other control limits specified in the method descriptions will be used by the laboratories to establish the acceptability of the data or the need for reanalysis of the samples. Laboratory control limits for recoveries of surrogate compounds, matrix spikes, and laboratory control samples, and for relative percent difference (RPD) of matrix spike duplicates and laboratory duplicates, are provided in each laboratory's QA manual (to be submitted under separate cover).

PARCC parameters (i.e., precision, accuracy or bias, representativeness, completeness, comparability) are commonly used to assess the quality of environmental data. Bias represents the degree to which a measured concentration conforms to the reference value. The results for matrix spikes, laboratory control samples, field blanks, and method blanks will be reviewed to evaluate bias of the data. The following calculation is used to determine percent recovery for a matrix spike sample:

$$\%R = [(M-U) / C] \times 100 \quad (1-1)$$

where:

%R = percent recovery

M = measured concentration in the spiked sample
U = measured concentration in the unspiked sample
C = concentration of the added spike

The following calculation is used to determine percent recovery for a laboratory control sample or reference material:

$$\%R = (M / C) \times 100 \quad (1-2)$$

where:

%R = percent recovery
M = measured concentration in the spiked sample
U = measured concentration in the unspiked sample
C = concentration of the added spike

Results for field and method blanks can reflect systematic bias that results from contamination of samples during collection or analysis. Any analytes detected in field or method blanks will be evaluated as potential indicators of bias.

Precision reflects the reproducibility between individual measurements of the same property. Precision will be evaluated using the results of matrix spike duplicates, laboratory duplicates, field splits, and field replicates. Precision is expressed in terms of the relative standard deviation for three or more measurements and the RPD for two measurements. The following equation is used to calculate the RPD between measurements:

$$RPD = |[(C1 - C2) / ((C1 + C2) / 2)]| \times 100 \quad (1-3)$$

where:

RPD = relative percent difference
C1 = first measurement
C2 = second measurement

The relative standard deviation is the ratio of the standard deviation of three or more measurements to the average of the measurements, expressed as a percentage.

Completeness will be calculated as the ratio of usable data (i.e., unqualified data and U- or J-qualified data) to generated data, expressed as a percentage. Completeness will be calculated for each suite of analytes for each sample type and sampling event.

Additional laboratory QC results will be evaluated to provide supplementary information regarding overall quality of the data, performance of instruments and measurement systems, and sample-specific matrix effects.

QC samples and procedures are specified in each method protocol that will be used for this project. Methods are summarized in Table 17. All QC requirements will be completed by each laboratory as described in the protocols, including the following (as applicable to each analysis):

- Instrument tuning
- Initial calibration
- Initial calibration verification
- Continuing calibration verification
- Calibration or instrument blanks
- Method blanks
- Laboratory control samples
- Internal standards
- Surrogate spikes/labeled compounds
- Matrix spikes
- Matrix spike duplicates or laboratory duplicates

To alert the data user to possible bias or imprecision, data qualifiers will be applied to reported analyte concentrations when associated QC samples or procedures do not meet control limits. Laboratory control limits for the methods that will be used for this Site investigation are provided in Table 17 and in the laboratory QA manuals (to be provided under separate cover). Data validation criteria and procedures are described in Section 4.

MRLs reflect the sensitivity of the analysis. Target MRLs for this study are summarized in Table 18 where possible. Some control limits cannot be specified until a laboratory has been selected.

MDLs will be determined by each laboratory for each analyte, as required by USEPA (2008a). MDLs are statistically derived and reflect the concentration at which an analyte can be detected in a clean matrix (e.g., sand or distilled water) with 99 percent confidence that a false positive result has not been reported. MRLs are established by the laboratories at levels above the MDLs for the project analytes. The MRL values are based on the laboratories' experience analyzing environmental samples and reflect the typical sensitivity obtained by the analytical system in environmental samples. For this task, the concentration of the lowest standard in the initial calibration curve for each analysis is at the level of the MRL. This allows reliable quantification of concentrations to the MRL in the absence of matrix interferences.

Dioxin and furan analyte concentrations for this task will be reported to the sample specific EDLs as described in USEPA method 8290A (USEPA 2008b). Other analyte concentrations will be reported to the MDL. Analytes detected at concentrations between the MRL and the EDL or MDL will be reported with a J qualifier to indicate that the value is an estimate (i.e., the analyte concentration is below the calibration range). Non-detects will be reported at the EDL for dioxins and furan congeners, and to the MRL for all other analyses. The MRLs, EDLs, and MDLs will be adjusted by each laboratory, as necessary, to reflect sample dilution, percent moisture, and/or matrix interference.

2.5.2.2 *Physical Properties Laboratory QA*

Duplicate specific gravity analyses and triplicate grain size analyses will be conducted on one of every 20 samples, or one per batch if less than 20 samples are analyzed. The precision of these replicate samples will be evaluated as described in Sections 2.5.2.1 and 4.1. No other QA procedures are applicable to the physical properties analyses.

2.5.2.3 *Representativeness and Comparability of All Data*

Representativeness and comparability are qualitative QA/QC parameters. Representativeness is the degree to which data represent a characteristic of an environmental condition. In the field, representativeness will be addressed primarily in the sampling design by the selection of sampling sites and sample collection procedures. In the laboratories, representativeness will be ensured by the proper handling and storage of samples and initiation of analysis within holding times.

Comparability is the qualitative similarity of one dataset to another (i.e., the extent to which different datasets can be combined for use). Comparability will be addressed through the use of field and laboratory methods that are consistent with methods and procedures recommended by USEPA and are commonly used for sediment studies.

2.6 Instrument and Equipment Testing, Inspection, and Maintenance

Analytical instrument testing, inspection, maintenance, setup, and calibration will be conducted by each laboratory in accordance with the requirements identified in the laboratory's SOPs and manufacturer instructions. In addition, each of the specified analytical methods provides protocols for proper instrument setup and tuning, and critical operating parameters. Instrument maintenance and repair will be documented in the maintenance log or record book.

2.7 Inspection and Acceptance of Supplies and Consumables

The quality of supplies and consumables used during sample collection and laboratory analysis can affect the quality of the project data. All equipment that comes into contact with the samples and extracts must be sufficiently clean to prevent detectable contamination, and the analyte concentrations must be accurate in all standards used for calibration and QC purposes.

During sample collection, the quality of laboratory water used for decontamination will be documented at the laboratory that provides that water. Precleaned sample jars (with documentation) will be provided by the laboratories. All containers will be visually inspected prior to use, and any suspect containers will be discarded.

Reagents of appropriate purity and suitably cleaned laboratory equipment will also be used for all stages of laboratory analyses. Details for acceptance requirements for supplies and consumables at the laboratories are provided in the laboratory SOPs and QA manuals (to be submitted under separate cover). All supplies will be obtained from reputable suppliers with appropriate documentation or certification. Supplies will be inspected to confirm that they meet use requirements, and certification records will be retained by Integral (i.e., for supplies used in the field) or the laboratories.

Sampling for parameters required by Study Element 4 does not require any additional inspection and acceptance of supplies beyond what is described in this section.

2.8 Non-Direct Measurements

Existing chemical data from previous investigations will be used for this study. As discussed in the RI/FS Work Plan, historical data will be reviewed for QA and acceptability for use in the RI/FS.

2.9 Data Management

During field, laboratory, and data evaluation operations, effective data management is critical to providing consistent, accurate, and defensible data and data products. Data management systems and procedures will be used to establish and maintain an efficient organization of the environmental information collected. Procedures and standards for conducting specific data management tasks (i.e., creation, acquisition, handling, storage, and distribution of data) will be documented in a project data management manual. Essential elements of data management and reporting activities associated with the sediment sampling program are discussed in the following sections.

Project data will be maintained in a relational database designed to accommodate all the types of environmental measurements that will be made during this RI/FS, as described in the data management plan, which is included as Appendix B of the RI/FS Work Plan. On-line access to the database will be provided to members of the project team and regulatory oversight bodies through a browser-based interface that provides information on the status

and contents of the project database, and that allows users to create custom data tables and maps.

2.9.1 *Field Data*

Daily field records (a combination of field logbooks, field forms, global positioning system [GPS] records, and COC forms) will make up the main documentation for field activities. Detailed guidelines for entry of information during field sampling are provided in the FSP, which is included as Appendix A to this SAP. Upon completion of sampling, hardcopy notes and forms will be scanned to create an electronic record for use in creating the draft PSCR. Information on sampling locations, dates, depths, equipment, and other conditions, and sample identifiers, will be entered into the project database. One hundred percent of hand-entered data will be verified based on hard copy records. Electronic QA checks to identify anomalous values will also be conducted following entry.

2.9.2 *Laboratory Data*

The analytical laboratories will each submit data in both electronic and hard-copy format. The project database administrator or his designated data manager will provide the desired format for EDDs to the laboratories, and the project data manager and laboratory coordinator will discuss these specifications with laboratory QA managers prior to data delivery and tailor them as necessary to specific laboratory capabilities. QA checks of format and consistency will be applied to EDDs received from the laboratory. After any issues have been resolved, the data will be loaded into the project database. Each dataset loaded will be linked to the electronic document of the relevant laboratory data package. Data summaries will be produced from the database for use by data validators. Validators will return edited versions of these summaries, and the edits will then be incorporated into the database. An automated change log will be maintained by the database so that the history of all such edits is maintained, and the provenance of each data value can be determined.

3 ASSESSMENT AND OVERSIGHT

This task will rely on the knowledge and expertise of the SJRWP technical team, as described in the RI/FS Work Plan. The field team and laboratories will stay in close verbal contact with the task manager and task QA coordinator during all phases of this task. This level of communication will serve to keep the management team informed about activities and events, and will allow for informal but continuous task oversight.

3.1 Assessment and Response Actions

Assessment activities will include readiness reviews by the field coordinator prior to sampling, by the database administrator prior to release of the final data to the data users, and internal review while work is in progress. An informal technical systems audit may be conducted if problems are encountered during any phase of this project.

The first readiness review will be conducted by the field lead prior to field sampling to verify that all field equipment is ready for transfer to the Site. The field lead will also verify that the field team and any subcontractors have been scheduled and briefed and that the contracts for the subcontractors have been signed by both parties. Any deficiencies noted during this readiness review will be corrected prior to initiation of sampling activities.

The second readiness review will be completed by the database administrator before final data are released for use to verify that all results have been received from each laboratory, data validation and data quality assessment have been completed for all of the data, and data qualifiers have been entered into the database and verified. Any deficiencies noted during this review will be corrected by the database administrator, the task QA coordinator, or their designee. Data will not be released for final use until all data have been verified and validated. No report will be prepared in conjunction with the readiness reviews. However, the SJRWP technical team coordinator and data users will be notified when the data are ready for use.

Technical review of intermediate and final work products generated for this task will be completed throughout the course of all sampling, laboratory, data validation, data management, and data interpretation activities to ensure that every phase of work is accurate

and complete and follows the QA procedures outlined in this QAPP. Any problems that are encountered will be resolved between the reviewer and the person completing the work. Any problems that cannot be easily resolved or that affect the final quality of the work product will be brought to the attention of the SJRWP technical team coordinator and SJRWP project coordinator.

Each laboratory will be required to have implemented a review system that serves as a formal surveillance mechanism for all laboratory activities. Details are provided in the laboratory QA plans (to be submitted under separate cover).

Technical system audits may be conducted if serious problems are encountered during sampling or analysis operations. If completed, these audits will be conducted by the task QA coordinator or designee, or by the laboratory, as appropriate. These audits may consist of on-site reviews of any phase of field or laboratory activities or data management. Results of any audits will be provided in the draft PSCR.

Any task team member who discovers or suspects a nonconformance is responsible for reporting the nonconformance to the task manager, the task QA coordinator, or the laboratory project or QA manager, as applicable. The task QA coordinator will ensure that no additional work dependent on the nonconforming activity is performed until a confirmed nonconformance is corrected. Any confirmed nonconformance issues will be relayed to the SJRWP technical team coordinator.

3.2 Reports to Management

The laboratories will keep the task laboratory coordinator informed of their progress on a weekly basis. The laboratories will provide the following information:

- Inventory and status of samples held at the laboratory in spreadsheet format by sample delivery group
- Summaries of any laboratory QC data outside of control limits and any corrective actions implemented
- Descriptions and justification for any significant changes in methodology or QA/QC procedures

The task laboratory coordinator will provide this information to the task QA coordinator, who will provide this information to the task manager.

Each laboratory will be required to have implemented routine systems of reporting nonconformance issues and their resolution. These procedures are described in the laboratory QA manuals (to be submitted under separate cover). Laboratory nonconformance issues will also be described in the draft PSCR if they affect the quality of the data.

Data packages and EDDs will be prepared by each laboratory upon completion of analyses for each sample delivery group. The case narrative will include a description of any problems encountered, control limit exceedances (if applicable), and a description and rationale for any deviations from protocol. Copies of corrective action reports generated at the laboratory will also be included with the data package.

Data validation reports will be prepared following receipt of the complete laboratory data packages for each sample delivery group. These reports will be provided to the task QA coordinator when validation is completed for each parameter. A summary of any significant data quality issues will be provided to USEPA with the data report.

4 DATA VALIDATION AND USABILITY

Data generated in the field and at the laboratories will be verified and validated according to criteria and procedures described in this section. Data quality and usability will be evaluated, and a discussion will be included in the data report.

4.1 Criteria for Data Review, Verification, and Validation

Field and laboratory data for this task will undergo a formal verification and validation process. All entries into the database will be verified. All errors found during the verification of field data, laboratory data, and the database will be corrected prior to release of the final data.

Data verification and validation for dioxins, metals, and organic compounds will be completed in accordance with Guidance on Environmental Data Verification and Validation (USEPA 2002a) and according to methods described in USEPA's functional guidelines for inorganic and organic data review (USEPA 2004a, 2005b, 2008a). Performance-based control limits established by the laboratories and control limits provided in the method protocols will be used to evaluate data quality and determine the need for data qualification. Performance-based control limits are established periodically by each laboratory. Current values will be provided in the laboratory QA plans (to be submitted under separate cover), as applicable.

No guidelines are available for validation of data for physical properties analyses and physical testing. These data will be validated using procedures described in the functional guidelines for inorganic data review (USEPA 2004a), as applicable, and their respective methods.

Results for field splits will be evaluated against a control limit of 50% RPD. Data will not be qualified as estimated if this control limit is exceeded, but RPD results will be tabulated, and any exceedances will be discussed in the draft PSCR. Equipment wipe blanks will be evaluated and data qualifiers will be applied in the same manner as method blanks, as described in the functional guidelines for data review (USEPA 2004a).

Data will be rejected if control limits for acceptance of data are not met, as described in USEPA (2004a, 2005b, 2008).

4.2 Verification and Validation Methods

Both the chemical and conventional analyses and the results of physical properties tests for Study Element 4 will undergo verification and validation, as described below.

4.2.1 Chemistry and Sediment Conventional

Field data will be verified during preparation of samples and COC forms. Field data and COC forms will be reviewed daily by the field lead. After field data are entered into the project database, 100 percent verification of the entries will be completed by a second party to ensure the accuracy and completeness of the database. Any discrepancies will be resolved before the final database is released for use.

Data verification and validation will be completed as described in Section 4.1 by either Integral or a data validation firm. The first data package generated for each analysis method will be fully validated, equivalent to a Stage 4 validation as described in USEPA (2009b). If no major problems are encountered during validation of this package, full validation will be completed at a rate of approximately 30 percent of the dioxin and furan samples and 10 percent of the samples analyzed for other parameters. Validation for the remaining data will be based on a review of the sample and QC data, equivalent to a Stage 2B validation. If problems are encountered, the laboratory will be contacted for resolution. Additional full validation will be completed if required to fully assess the quality of the data to verify that the laboratory errors have been addressed.

The accuracy and completion of the database will be verified at each laboratory when the EDDs are prepared and again as part of data validation. Ten percent of entries to the database from laboratory EDDs will be checked against hard-copy data packages. In addition to verification of field and laboratory data and information, data qualifier entries into the database will be verified. Any discrepancies will be resolved before the final database is released for use.

Reporting limits for non-detects will be compared to the MRL goals to evaluate method sensitivity for each sample. Any exceedance of actual MRLs over the target MRLs will be discussed in the data report.

4.2.2 Results of Physical Properties Tests

Data verification and validation will be completed as described in Section 4.1 by either Integral or a data validation firm. The first data package generated for each analysis method will be validated to a level similar to a Stage 3 validation as described in USEPA (2009b), as applicable to the method. If no major problems are encountered during validation of this package, Stage 3 validation will be completed at a rate of approximately 10 percent of the samples analyzed. Validation for the remaining data will be based on a review of the sample and QC data, equivalent to a Stage 2A validation, as applicable to the method. If problems are encountered, the laboratory will be contacted for resolution. Additional Stage 3 validation will be completed if required to fully assess the quality of the data to verify that the laboratory errors have been addressed.

The accuracy and completion of the database will be verified at each laboratory when the EDDs are prepared and again as part of data validation. Ten percent of entries to the database from laboratory EDDs will be checked against hard-copy data packages. In addition to verification of field and laboratory data and information, data qualifier entries into the database will be verified. Any discrepancies will be resolved before the final database is released for use.

4.3 Reconciliation with User Requirements

Both the chemical and conventional analyses and the results of physical properties tests for Study Element 4 will undergo reconciliation with user requirements, as described below.

4.3.1 Chemistry and Sediment Conventional

The goal of data validation is to determine the quality of each data result and to identify those that do not meet the task measurement quality objectives. Nonconforming data may be qualified as estimated (i.e., a J qualifier will be applied to the result) or rejected as unusable (i.e., an R qualifier will be applied to the result) during data validation if criteria for

data quality are not met. Rejected data will not be used for any purpose. An explanation of the rejected data will be included in the draft PSCR.

Data qualified as estimated will be used for all intended purposes and will be appropriately qualified in the final project database. However, these data are less precise or less accurate than unqualified data. Data users, in cooperation with the SJRWP technical team coordinator and the task QA coordinator, are responsible for assessing the effect of the inaccuracy or imprecision of the qualified data on statistical procedures and other data uses.

4.3.2 *Results of Physical Properties Tests*

Protocols for data validation from geotechnical testing are not established; specific validation procedures will not be used for Study Element 4 laboratory results.

5 REFERENCES

- Anchor QEA. 2009. Health and Safety Plan San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Anchor QEA, Ocean Springs, MS.
- APHA. 1998. Standard Methods for the Analysis of Water and Wastewater. 20th Edition. American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, DC. 1268 pp.
- ASTM. 2009. Annual Book of ASTM Standards. Volume 04.08. American Society for Testing and Materials, Philadelphia, PA.
- ENSR and EHA. 1995. Houston Ship Channel Toxicity Study. Prepared for the City of Houston, Houston, TX. ENSR Consulting and Engineering, Houston, TX and Espey, Huston and Associates, Austin, TX.
- Barber, T.R., D.J. Chappie, D.J. Duda, P.C. Fuchsman, and B.L. Finley. 1998. Using a Spiked Sediment Bioassay to Establish a No-Effect Concentration for Dioxin Exposure to the Amphipod Ampelisca abdita. *Environmental Toxicology and Chemistry* 17:420-424.
- Fuchsman, P.C., T.R. Barber, J.C. Lawton, and K.B. Leigh. 2006. An Evaluation of Cause-Effect Relationships Between Polychlorinated Biphenyl Concentrations and Sediment Toxicity to Benthic Invertebrates. *Environmental Toxicology and Chemistry* 25 (10):2601-2612.
- Gardiner, J., B. Azzato and M. Jacobi (eds). 2008. Coastal and Estuarine Hazardous Waste Site Reports. September 2008. National Oceanic and Atmospheric Administration, Office of Response and Restoration, Assessment and Restoration Division, Seattle, WA. 148 pp.
- Gonzales, A.G. 2007. Use and Misuse of Supervised Pattern Recognition Methods for Interpreting Compositional Data. *J. Chromatogr. A* 1158:215-225.
- Hydrographic Consultants. 2009. Bathymetric Survey Performed at the SJRWP Site. Hydrographic Consultants, Bellaire, TX.

- Litteer, D. 2009. *Baytown Nature Center Bird Checklist*.
http://www.baytownnaturecenter.org/publications_information/bird_checklist.html.
Accessed January 7, 2009.
- Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. *Environmental Management* 19(1):81-97.
- Louchouart, P., and R. Brinkmeyer. 2009. Fate of Dioxin in the Houston Ship Channel and Evaluation of Natural Remediation Processes. Prepared for Texas Commission on Environmental Quality, Total Maximum Daily Load Program, Austin, TX. Texas A&M University at Galveston, Galveston, TX.
- Myers, J.C. 1997. Geostatistical Error Management: Quantifying Uncertainty for Environmental Sampling and Mapping. Van Nostrand Reinhold Publishing, New York, NY.
- NCASI. 1992. Chemical Composition of Pulp and Paper Industry Landfill Leachates. Technical Bulletin No. 643. National Council of the Paper Industry for Air and Stream Improvement, Inc., New York, NY.
- NCASI. 1999. A Summary of Available Data on the Chemical Composition of Forest Products Industry Solid Wastes. Special Report No. 99-04. National Council of the Paper Industry for Air and Stream Improvement, Inc., Research Triangle Park, NC.
- NIH. 2010. Hazardous Substances Data Bank Online Database.
<http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?/temp/~CdZaEH:1>. Accessed January 11, 2010. Last updated Aug 30, 2006. National Institutes of Health, Department of Health and Human Services, Bethesda, MD.
- NOS. 1995. Survey H1016. National Geophysical Data Center integrated National Ocean Service hydrographic survey data into GEODAS' (Geophysical Data System) data management system. <http://www.ngdc.noaa.gov/mgg/dat/geodas/docs/hyd93.htm>.
- Orion. 2009. Analytical Results for Sediment Samples from the Water Front of Sneed Shipbuilding. Orion Diving and Salvage.
- Osborn, M., P. Chai, A. Green, J. Lin, C. Loeffler, A. Morgan, P. Rubec, S. Spanyers, and A. Walton. 1992. Fisheries: In Status and Trends of Selected Living Resources in the

- Galveston Bay System. GBNEP-19C. Loeffler and A. Walton (eds). Galveston Bay National Estuary Program, Webster, TX.
- Suntio, L.R., W.Y. Shiu, D. Mackay. 1988. A Review of the Nature and Properties of Chemicals Present in Pulp Mill Effluents. University of Toronto, Institute for Environmental Studies, Toronto, Ontario, Canada. *Chemosphere* 17(7):1249-1290.
- TCEQ. 2003. Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data, 2004. Texas Commission on Environmental Quality, Surface Water Quality Monitoring Program, Austin, TX. Available at:
www.tnrcc.state.tx.us/water/quality/305_303.html.
- TCEQ. 2006. Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites In Texas RG-263 (Revised). Remediation Division. January.
<http://www.tceq.state.tx.us/assets/public/remediation/eco/0106eragupdate.pdf>
- TCEQ and USEPA. 2006. Screening Site Assessment Report San Jacinto River Waste Pits, Channelview, Harris County, Texas. TXN000606611. Texas Commission on Environmental Quality and U.S. Environmental Protection Agency.
- TNRCC. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Texas Natural Resource Conservation Commission, Toxicology and Risk Assessment Section.
- University of Houston and Parsons. 2006. Total Maximum Daily Loads for Dioxins in the Houston Ship Channel. Contract No. 582-6-70860, Work Order No. 582-6-70860-02. Quarterly report No. 3. Prepared in cooperation with the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency. University of Houston and Parsons Water & Infrastructure. Available at:
<http://www.tceq.state.tx.us/assets/public/implementation/water/tmdl/26hscdioxin/26-all-data-compiled-q3-fy06.pdf>.
- URS. 2010. Data Usability Summary: Surface Water and Sediment Samples, San Jacinto River Waste Pits Superfund Site, Channelview, Harris County, TX. Prepared for TCEQ. URS Corporation, Houston, TX.
- Usenko, S., B. Brooks, E. Bruce, and S. Williams. 2009. Defining Biota-Sediment Accumulation Factors for the San Jacinto River Waste Pits, Texas Project Work Plan

- and QA/QC Procedures. Baylor University, Center for Reservoir and Aquatic Systems Research and the Department of Environmental Science, Waco, TX.
- USEPA. 1986. Puget Sound Estuary Program: Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. Final Report. Prepared for U.S. EPA, Region 10, Office of Puget Sound, Seattle, WA and the U.S. Army Corps of Engineers, Seattle District, Seattle, WA. Tetra Tech, Inc., Bellevue, WA.
- USEPA. 1988a. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 1988b. U.S. EPA/Paper Industry Cooperative Dioxin Screening Study. EPA-440/1-88-025. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC.
- USEPA. 1991. Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals). EPA/540/R-93/003. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC. December.
- USEPA. 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. Publication 9285.7-081. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.
- USEPA. 1994. Method 1613, Tetra- Through Octa-chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS. U.S. Environmental Protection Agency, Office of Water, Washington, DC.
- USEPA. 1997a. Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments. USEPA 540-R-97-006. U.S. Environmental Protection Agency, Solid Waste and Emergency Response, Washington, DC.
- USEPA. 1997b. Recommended Quality Assurance and Quality Control Guidelines for the Collection of Environmental Data in Puget Sound. In: Recommended protocols for measuring selected environmental variables in Puget Sound. U.S. Environmental Protection Agency, Puget Sound Estuary Program, Seattle WA.

- USEPA. 1998. EPA Guidance for Quality Assurance Project Plans. EPA QA/G-5. U.S. Environmental Protection Agency, Washington, DC.
- USEPA. 2000. Exposure and Human Health Reassessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds. EPA/600/P-00/001Bc. Draft Final Report. U.S. Environmental Protection Agency, National Center for Environmental Assessment, Washington, DC.
- USEPA. 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5. EPA/240/B-01/003. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.
- USEPA. 2002a. Guidance on Environmental Data Verification and Validation. EPA QA/G-8. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.
- USEPA. 2002b. Guidance for Quality Assurance Project Plans. EPA QA/G-5. EPA/240/R-02/009. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.
- USEPA. 2004a. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 2004b. USEPA. Dioxin Reassessment. National Academy of Sciences (NAS) Review Draft. EPA/600/P-00/001Cb. U.S. Environmental Protection Agency, Washington, DC.
- USEPA. 2005a. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. EPA-540-R-05-012. OSWER 9355.0-85. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.
- USEPA. 2005b. USEPA Contract Laboratory Program Functional Guidelines for Chlorinated Dioxin/Furan Data Review. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4. EPA/240/B-06/001. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

- USEPA. 2008a. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 2008b. SW-846 On-line, Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. U.S. Environmental Protection Agency. <http://www.epa.gov/epaoswer/hazwaste/test/main.htm>. (Accessed December 28, 2009).
- USEPA. 2008c. Using Fish Tissue Data to Monitor Remedy Effectiveness. OSWER Directive 9200.1-77D. Sediment Assessment and Monitoring Sheet (SAMS) #1. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation and Office of Research and Development, Washington, DC.
- USEPA. 2009a. Unilateral Administrative Order for Remedial Investigation/Feasibility Study. U.S. EPA Region 6 CERCLA Docket No. 06-03-10. In the matter of: San Jacinto River Waste Pits Superfund Site Pasadena, Texas. International Paper Company, Inc. & McGinnes Industrial Management Corporation, respondents.
- USEPA. 2009b. USEPA Contract Laboratory Program Functional Guidelines for Superfund Organic Methods Data Review. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA et al. 2009. Public Announcement. Permit evaluation requirement process for all proposed and existing permits within the Area of Concern at the San Jacinto River Waste Pits Superfund Site. October 21, 2009. U.S. Environmental Protection Agency, Region 6; U.S. Army Corps of Engineers, Galveston District; and Texas Commission on Environmental Quality.
- USFWS. 2009. Amphibians and Reptiles of Trinity River National Wildlife Refuge. <http://www.fws.gov/southwest/refuges/texas/trinityriver/Docs/TRNWRHerps2009.pdf> Accessed on January 4, 2010. U.S. Fish and Wildlife Service, Fish and Wildlife Refuge.
- USGS. 2009. Geochemistry of Sediments in the US. NURE-HSSR database, <http://tin.er.usgs.gov/nure/sediment/>. Accessed January 5, 2010.

- Weston. 2006. Draft Field Activities Report for Sediment Sampling. San Jacinto River Bridge Dolphin Project IH-10 at the San Jacinto River. Prepared for the Texas Department of Transportation, Environmental Affairs Division, Austin, TX. Weston Solutions, Inc., Houston, Texas.
- Wiegand, P. 2010. Personal Communication (telephone conversation with J. Sampson, Integral Consulting Inc., Seattle, WA, on January 6, 2010, regarding chemical composition of solid wastes that are generated by bleach kraft pulp mills.) National Council of the Paper Industry for Air and Stream Improvement, Inc., Raleigh, NC.

TABLES

Table 1
Datasets with Information Evaluated for the San Jacinto River Waste Pits Site

Source of Sediment Chemistry Data	Media Sampled	Sampling Dates	Chemicals Analyzed	Area Sampled	Citation
TCEQ SJRWP Site Sampling	Sediment ^a	Aug 20, 2009	Dioxins/Furans	4 sediment stations (5 samples, 1 a field duplicate) and 3 surface water samples in Site, within and adjacent to impoundments	URS (2010)
Sneed Shipbuilding Sediment Sampling	Sediment	May and Nov 2009	Dioxins/Furans	15 sediment samples collected from waterfront adjacent to Sneed Shipbuilding, downstream of Site	Orion (2009)
Texas Department of Transportation Dolphin Project	Sediment	May - June 2006	Dioxins/Furans, Metals, SVOCs, PCBs	4 sediment cores and 8 surface sediment samples in San Jacinto River just upstream of Interstate Highway 10	Weston (2006)
TCEQ Site Screening Investigation	Sediment	July 2005	Dioxins/Furans, Metals, PAH, SVOCs, Pesticides, PCBs	6 stations in the Impoundments (7 samples, 1 a field duplicate), 3 stations downstream and within the Site, additional upstream and downstream background locations outside of the Site	TCEQ and US EPA (2006)
TCEQ TMDL Study	Sediment ^a	2002-2005	Dioxins/Furans	Sampling throughout the HSC; 1 station adjacent to the Site (11193) sampled for surface sediment multiple times (this is a monitoring station), and 1 core sample collected in 2004; 21 additional surface sediment samples on Site collected in August, 2005	University of Houston and Parsons (2006)
HSC Toxicity Study	Sediment	Aug and Oct 1993, May 1994	Dioxins/Furans	35 Stations along the HSC and major tributaries; two stations are located in the Site, 1 in the channel adjacent to the impoundments and one upstream of waste pits	ENSR and EHA (1995)

Notes

HSC = Houston Ship Canal

SJRWP = San Jacinto River Waste Pit

TCEQ = Texas Commission on Environmental Quality

TMDL = total maximum daily load

^a Tissue and/or surface water were also collected by this program. Those data are addressed in the RI/FS work plan.

Table 2
Number of Surface Sediment and Core Sampling Locations by Study

Location ^a	Study	Number of Locations ^b	
		Surface	Core
Site	ENSR and EHA (1995)	1	0
Site	TCEQ and USEPA (2006)	9	0
Site	URS (2010)	4	0
Site	University of Houston and Parsons (2006)	24	1
Site	Weston (2006)	8	4
Study Area	ENSR and EHA (1995)	2	0
Study Area	Orion (2009)	15	0
Study Area	TCEQ and USEPA (2006)	5	0
Study Area	University of Houston and Parsons (2006)	4	0

Notes

^a "Site" is within the boundary established in the Unilateral Administrative Order; "Study Area" is a large area in the San Jacinto River, as shown in Figure 5.

^b The number of locations may differ from the number of samples if a location was sampled more than once.

Table 3
Number of Locations Sampled by Zone, Study, and Analyte

Matrix	Zone ^a	Study	Number of Locations Sampled					
			Dioxins and Furans	Metals	PCBs	Pesticides	PAH	Semivolatiles
Sediment								
	Site	ENSR and EHA (1995)	1					
	Site	TCEQ and USEPA (2006)	9	9	9	9	9	9
	Site	URS (2010)	4					
	Site	University of Houston and Parsons (2006) ^b	24					
	Site	Weston (2006) ^c	12	12	12		12	12
	Study Area	ENSR and EHA (1995)	2					
	Study Area	Orion (2009)	15					
	Study Area	TCEQ and USEPA (2006)	5	5	5	5	5	5
	Study Area	University of Houston and Parsons (2006)	4					

Notes

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

TMDL = total maximum daily load

^a"Site" is within the boundary established in the Unilateral Administrative Order; "Study Area" is a large area in the San Jacinto River, as shown in Figure 5.

^b At one of these stations (11193), a core was also collected.

^c Eight of these samples are surface sediments; four are cores co-located with four of the surface sediments. Cores were analyzed at multiple depth increments.

Table 4
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
Dioxins/Furans				
2,3,7,8-TCDD	1746-01-6	alpha-Chlordane	Pesticide	5103-71-9
Metals				
Aluminum	7429-90-5	gamma-chlordane	Pesticide	5103-74-2
Antimony	7440-36-0	Endrin ketone	Pesticide	53494-70-5
Arsenic	7440-38-2	Methoxychlor	Pesticide	72-43-5
Barium	7440-39-3	4,4'-DDD	Pesticides	72-54-8
Beryllium	7440-41-7	4,4'-DDE	Pesticides	72-55-9
Cadmium	7440-43-9	4,4'-DDT	Pesticides	50-29-3
Chromium	7440-47-3	Aldrin	Pesticides	309-00-2
Cobalt	7440-48-4	alpha-BHC	Pesticides	319-84-6
Copper	7440-50-8	Endosulfan I	Pesticides	959-98-8
Iron	7439-89-6	beta-BHC	Pesticides	319-85-7
Lead	7439-92-1	Endosulfan II	Pesticides	33213-65-9
Magnesium	7439-95-4	Chlordane	Pesticides	57-74-9
Manganese	7439-96-5	delta-BHC	Pesticides	319-86-8
Mercury	7439-97-6	Dieldrin	Pesticides	60-57-1
Nickel	7440-02-0	Endosulfan sulfate	Pesticides	1031-07-8
Potassium	7440-09-7	Endrin	Pesticides	72-20-8
Selenium	7782-49-2	Endrin aldehyde	Pesticides	7421-93-4
Sodium	7440-23-5	gamma-BHC (Lindane)	Pesticides	58-89-9
Silver	7440-22-4	Heptachlor	Pesticides	76-44-8
Thallium	7440-28-0	Heptachlor epoxide	Pesticides	1024-57-3
Vanadium	7440-62-2	Toxaphene	Pesticides	8001-35-2
Zinc	7440-66-6	1,2,4-Trichlorobenzene	VOC	120-82-1
PCBs				
Polychlorinated Biphenyls	various	1,2-Dichlorobenzene	VOC	95-50-1

Table 4
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
SVOCs				
Acenaphthene	83-32-9	1,3-Dichlorobenzene	VOC	541-73-1
Acenaphthylene	208-96-8	1,4-Dichlorobenzene	VOC	106-46-7
Anthracene	120-12-7	1,1,1-Trichloroethane	VOC	71-55-6
Benzo(a)anthracene	56-55-3	1,1,2,2-Tetrachloroethane	VOC	79-34-5
Benzo(a)pyrene	50-32-8	1,1,2-Trichloroethane	VOC	79-00-5
Benzo(b)fluoranthene	205-99-2	1,1-Dichloroethane	VOC	75-34-3
Benzo(g,h,i)perylene	191-24-2	1,1-Dichloroethene	VOC	75-35-4
Benzo(k)fluoranthene	207-08-9	1,2-Dichloroethane	VOC	107-06-2
Chrysene	218-01-9	1,2-Dichloropropane	VOC	78-87-5
Dibenzo(a,h)anthracene	53-70-3	trans-1,2-Dichloroethene	VOC	156-60-5
Fluoranthene	206-44-0	1,2-dichloropropylene	VOC	542-75-6
Fluorene	86-73-7	2-chloroethyl vinyl ethers	VOC	110-75-8
Indeno(1,2,3-cd)pyrene	193-39-5	Acrolein	VOC	107-02-8
Naphthalene	91-20-3	Acrylonitrile	VOC	107-13-1
Phenanthrene	85-01-8	Benzene	VOC	71-43-2
Pyrene	129-00-0	Bromoform	VOC	75-25-2
2,4,6-Trichlorophenol	88-06-2	Carbon tetrachloride	VOC	56-23-5
2,4-Dichlorophenol	120-83-2	Chlorobenzene	VOC	108-90-7
2,4-Dimethylphenol	105-67-9	Chlorodibromomethane	VOC	124-48-1
2,4-Dinitrophenol	51-28-5	Chloroethane	VOC	75-00-3
2-Chlorophenol	95-57-8	Chloroform	VOC	67-66-3
2-Nitrophenol	88-75-5	Dibromochloromethane	VOC	124-48-1
4-Nitrophenol	100-02-7	Ethylbenzene	VOC	100-41-4
Pentachlorophenol	87-86-5	Bromomethane	VOC	74-83-9
Phenol	108-95-2	Chloromethane	VOC	74-87-3
Bis(2-ethylhexyl)phthalate	117-81-7	Methylene chloride	VOC	75-09-2

Table 4
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
Butylbenzylphthalate	85-68-7	Tetrachloroethene	VOC	127-18-4
Diethylphthalate	84-66-2	Toluene	VOC	108-88-3
Dimethylphthalate	131-11-3	Trichloroethene	VOC	79-01-6
Di-n-butylphthalate	84-74-2	Vinyl chloride	VOC	75-01-4
Di-n-octylphthalate	117-84-0	Styrene	VOC	100-42-5
37. 1,2-diphenylhydrazine	122-66-7	cis-1,3-Dichloropropene	VOC	10061-01-5
2,4-Dinitrotoluene	121-14-2	trans-1,3-dichloropropene	VOC	10061-02-6
2,6-Dinitrotoluene	606-20-2	1,2-Dibromoethane	VOC	106-93-4
2-Chloronaphthalene	91-58-7	4-Methyl-2-pentanone	VOC	108-10-1
3,3'-Dichlorobenzidine	91-94-1	Methylcyclohexane	VOC	108-87-2
4,6-Dinitro-2-methylphenol	534-52-1	Cyclohexane	VOC	110-82-7
4-Bromophenyl-phenylether	101-55-3	1,2,4-Trichlorobenzene	VOC	120-82-1
4-Chlorophenyl-phenyl ether	7005-72-3	1,4-Dioxane	VOC	123-91-1
Benzidine	92-87-5	cis-1,2-Dichloroethene	VOC	156-59-2
Bis(2-chloroethoxy) methane	111-91-1	Methyl tert-butyl ether	VOC	1634-04-4
Bis(2-chloroethyl)ether	111-44-4	m,p-Xylene	VOC	179601-23-1
Bis(2-chloroisopropyl) ether	39638-32-9	2-Hexanone	VOC	591-78-6
Hexachlorobenzene	118-74-1	Acetone	VOC	67-64-1
Hexachlorobutadiene	87-68-3	Bromochloromethane	VOC	74-97-5
Hexachlorocyclo-pentadiene	77-47-4	Carbon disulfide	VOC	75-15-0
Hexachloroethane	67-72-1	Bromodichloromethane	VOC	75-27-4
Isophorone	78-59-1	Trichlorofluoromethane	VOC	75-69-4
Nitrobenzene	98-95-3	Dichlorodifluoromethane	VOC	75-71-8
N-nitrosodimethylamine	62-75-9	1,1,2-Trichloro-1,2,2-trifluoroethane	VOC	76-13-1
N-Nitroso-di-n propylamine	621-64-7	2-Butanone	VOC	78-93-3
N-Nitrosodiphenylamine	86-30-6	Methyl acetate	VOC	79-20-9
4-Chloro-3-methylphenol	59-50-7	1,2,3-Trichlorobenzene	VOC	87-61-6

Table 4
Priority Pollutant List

TAL Metals, Polychlorinated Biphenyls (PCBs), and Semivolatile Organic Compounds (SVOCs)	CAS RN	CLP Pesticides and Volatile Organic Compounds (VOCs)	Group	CAS RN
4-Nitroaniline	100-01-6	o-Xylene	VOC	95-47-6
Benzaldehyde	100-52-7	1,2-Dibromo-3-chloropropane	VOC	96-12-8
Caprolactam	105-60-2	Isopropylbenzene	VOC	98-82-8
4-Methylphenol	106-44-5	Cyanide, Total	Conventionals	57-12-5
4-Chloroaniline	106-47-8			
2,2'-Oxybis(1-chloropropane)	108-60-1			
Dibenzofuran	132-64-9			
Atrazine	1912-24-9			
2,3,4,6-Tetrachlorophenol	58-90-2			
Carbazole	86-74-8			
2-Nitroaniline	88-74-4			
2-Methylnaphthalene	91-57-6			
1,1'-Biphenyl	92-52-4			
2-Methylphenol	95-48-7			
1,2,4,5-Tetrachlorobenzene	95-94-3			
2,4,5-Trichlorophenol	95-95-4			
Acetophenone	98-86-2			
3-Nitroaniline	99-09-2			

Notes

CLP = Contract Laboratory Program

TAL = target analyte list

VOC = volatile organic compound

Table 5
Chemicals of Interest

Class	Chemical
Dioxins/Furans	
	Dioxins and Furans
Metals	
	Aluminum
	Antimony
	Arsenic
	Barium
	Cadmium
	Chromium
	Cobalt
	Copper
	Lead
	Magnesium
	Manganese
	Mercury
	Nickel
	Silver
	Thallium
	Vanadium
	Zinc
PCBs	
	Polychlorinated Biphenyls
SVOCs	
	Acenaphthene
	Fluorene
	Naphthalene
	Phenanthrene
	2,4,6-Trichlorophenol
	2,4-Dichlorophenol
	Pentachlorophenol
	Phenol
	2,4-Dinitrotoluene
	2,6-Dinitrotoluene
	Hexachlorobenzene
	2,3,4,6-Tetrachlorophenol
	Carbazole
	2,4,5-Trichlorophenol
VOCs	
	Chloroform

Notes

PCB = polychlorinated biphenyl

SVOC = semivolatile organic compound

VOC = volatile organic compound

Table 6
Chemicals Potentially Associated with Bleached Pulp Mill Waste

COIs and SSI Analytes ^a	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Summary: Chemicals Potentially Associated with Bleached Pulp Mill Waste
Dioxins/Furans				
Dioxins and Furans	X	X		X
Metals				
Aluminum		X	X	X
Antimony				
Arsenic		X	X	X
Barium		X	X	X
Beryllium				
Cadmium		X		X
Chromium		X		X
Cobalt		X		X
Copper		X	X	X
Lead		X	X	X
Magnesium		X	X	X
Manganese		X	X	X
Mercury	X	X	X	X
Nickel		X	X	X
Selenium				
Silver				
Thallium			X	X
Vanadium				
Zinc		X	X	X
Polychlorinated Biphenyls				
Polychlorinated Biphenyls		X		X

Table 6
Chemicals Potentially Associated with Bleached Pulp Mill Waste

COIs and SSI Analytes ^a	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Summary: Chemicals Potentially Associated with Bleached Pulp Mill Waste
Semivolatile Organic Compounds				
Acenaphthene		X		X
Acenaphthylene				
Anthracene				
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Chrysene				
Dibenzo(a,h)anthracene				
Fluoranthene				
Fluorene		X		X
Indeno(1,2,3-cd)pyrene				
Naphthalene		X		X
Phenanthrene		X		X
Pyrene				
2,4,6-Trichlorophenol	X	X	X	X
2,4-Dichlorophenol	X	X		X
2,4-Dimethylphenol				
2,4-Dinitrophenol				X
2-Chlorophenol	X	X		X
2-Nitrophenol				
4-Nitrophenol				
Pentachlorophenol	X	X		X
Phenol		X		X

Table 6
Chemicals Potentially Associated with Bleached Pulp Mill Waste

COIs and SSI Analytes ^a	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Summary: Chemicals Potentially Associated with Bleached Pulp Mill Waste
2,4-Dinitrotoluene				X
2,6-Dinitrotoluene				X
Hexachlorobenzene				X
4-Methylphenol			X	X
4-Chloroaniline				
2,2'-Oxybis(1-chloropropane)				
Dibenzofuran				
Atrazine				
2,3,4,6-Tetrachlorophenol	X			X
Carbazole		X		X
2-Nitroaniline				
2-Methylnaphthalene				
1,1'-Biphenyl				
2-Methylphenol			X	X
2,4,5-Trichlorophenol	X	X	X	X
Volatile Organic Compounds				
1,2,4-Trichlorobenzene				
1,2-Dichlorobenzene				
1,3-Dichlorobenzene				
1,4-Dichlorobenzene				
1,1,1-Trichloroethane				
1,1,2,2-Tetrachloroethane				
1,2-Dichloroethane				
Benzene				
Carbon tetrachloride				
Chlorobenzene				

Table 6
Chemicals Potentially Associated with Bleached Pulp Mill Waste

COIs and SSI Analytes ^a	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Summary: Chemicals Potentially Associated with Bleached Pulp Mill Waste
Chloroform		X		X
Ethylbenzene				
Tetrachloroethene				
Toluene			X	X
Trichloroethene				

Notes

CLP = Contract Laboratory Program

COI = chemical of interest

CWA PPL = Clean Water Act priority pollutant list

SSI - Screening Site Inspection Report

TAL = target analyte list

X = yes

^aCombination of the priority pollutant list and the analytes in TCEQ and USEPA (2006)

Table 7
Summary of Chemicals of Interest and Steps to Evaluate Detections, Persistence,
and Potential Association with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Association with Pulp Mill Waste							
	Analyzed in Site Sediments (TCEQ and USEPA 2006)	Ever Detected in Site Sediments (TCEQ and USEPA 2006)	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Chemicals Potentially Associated with Pulp Mill Waste ^a	Organic Chemicals Potentially Associated with Bleached Pulp Mill Waste and Expected to Persist in Sediment ^b	COI
Dioxins and Furans	X	X	X	X		X	X	X
Metals								
Aluminum	X	X		X	X	X	NA	X
Antimony	X	X				O	NA	X
Arsenic	X	X		X	X	X	NA	X
Barium	X	X		X	X	X	NA	X
Beryllium	X	O				O	NA	
Cadmium	X	X		X		X	NA	X
Chromium	X	X		X		X	NA	X
Cobalt	X	X		X		X	NA	X
Copper	X	X		X	X	X	NA	X
Lead	X	X		X	X	X	NA	X
Magnesium	X	X		X	X	X	NA	X
Manganese	X	X		X	X	X	NA	X
Mercury	X	X	X	X	X	X	NA	X
Nickel	X	X		X	X	X	NA	X
Selenium	X	O				O	NA	
Silver	X	X				O	NA	X
Thallium	X	O			X	X	NA	X
Vanadium	X	X				O	NA	X
Zinc	X	X		X	X	X	NA	X
Polychlorinated Biphenyls	X	O		X		X	X	X

Table 7
Summary of Chemicals of Interest and Steps to Evaluate Detections, Persistence,
and Potential Association with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Association with Pulp Mill Waste							
	Analyzed in Site Sediments (TCEQ and USEPA 2006)	Ever Detected in Site Sediments (TCEQ and USEPA 2006)	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Chemicals Potentially Associated with Pulp Mill Waste ^a	Organic Chemicals Potentially Associated with Bleached Pulp Mill Waste and Expected to Persist in Sediment ^b	COI
Semivolatile Organic Compounds								
Acenaphthene	X	O		X		X	X	X
Acenaphthylene	X	O				O	O	
Anthracene	X	O				O	NA	
Benzo(a)anthracene	X	O				O	NA	
Benzo(a)pyrene	X	O				O	NA	
Benzo(b)fluoranthene	X	O				O	NA	
Benzo(g,h,i)perylene	X	O				O	NA	
Benzo(k)fluoranthene	X	O				O	NA	
Chrysene	X	O				O	NA	
Dibenzo(a,h)anthracene	X	O				O	NA	
Fluoranthene	X	O				O	NA	
Fluorene	X	O		X		X	X	X
Indeno(1,2,3-cd)pyrene	X	O				O	NA	
Naphthalene	X	O		X		X	X	X
Phenanthrene	X	O		X		X	X	X
Pyrene	X	O				O	NA	
2,4,6-Trichlorophenol	X	O	X	X	X	X	X	X
2,4-Dichlorophenol	X	O	X	X		X	X	X
2,4-Dimethylphenol	X	O				O	NA	
2,4-Dinitrophenol	X	O				X	O	
2-Chlorophenol	X	O	X	X		X	O	
2-Nitrophenol	X	O				O	NA	
4-Nitrophenol	X	O				O	NA	

Table 7
Summary of Chemicals of Interest and Steps to Evaluate Detections, Persistence,
and Potential Association with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Association with Pulp Mill Waste							
	Analyzed in Site Sediments (TCEQ and USEPA 2006)	Ever Detected in Site Sediments (TCEQ and USEPA 2006)	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Chemicals Potentially Associated with Pulp Mill Waste ^a	Organic Chemicals Potentially Associated with Bleached Pulp Mill Waste and Expected to Persist in Sediment ^b	COI
Pentachlorophenol	X	O	X	X		X	X	X
Phenol	X	O		X		X	X	X
2,4-Dinitrotoluene	X	O				X	X	X
2,6-Dinitrotoluene	X	O				X	X	X
Hexachlorobenzene	X	O				X	X	X
4-Methylphenol	X	O			X	X	O	
4-Chloroaniline	X	O				O	NA	
2,2'-Oxybis(1-chloropropane)	X	O				O	NA	
Dibenzofuran	X	O				O	NA	
Atrazine	O	NA				O	NA	
2,3,4,6-Tetrachlorophenol	O	NA	X			X	X	X
Carbazole	O	NA		X		X	X	X
2-Nitroaniline	X	O				O	NA	
2-Methylnaphthalene	X	O				O	NA	
1,1'-Biphenyl	X	O				O	NA	
2-Methylphenol	X	O			X	X	O	
2,4,5-Trichlorophenol	X	O	X	X	X	X	X	X

Table 7
Summary of Chemicals of Interest and Steps to Evaluate Detections, Persistence,
and Potential Association with Bleached Pulp Mill Waste

TAL Metals, CLP Chemicals and CWA PPL	Association with Pulp Mill Waste							
	Analyzed in Site Sediments (TCEQ and USEPA 2006)	Ever Detected in Site Sediments (TCEQ and USEPA 2006)	Generally in Bleached Pulp Mill Waste (Wiegand 2010, pers. comm.)	NCASI (1999) Solid Wastes	NCASI (1992) Leachates	Chemicals Potentially Associated with Pulp Mill Waste ^a	Organic Chemicals Potentially Associated with Bleached Pulp Mill Waste and Expected to Persist in Sediment ^b	COI
Volatile Organic Compounds								
1,2,4-Trichlorobenzene	O	NA		X		O	NA	
1,2-Dichlorobenzene	O	NA		X		O	NA	
1,3-Dichlorobenzene	O	NA		X		O	NA	
1,4-Dichlorobenzene	O	NA		X		O	NA	
Benzene	O	NA		X		O	NA	
Chloroform	O	NA		X		X	X	X
Toluene	O	NA		X	X	X	O	

Notes

CLP = Contract Laboratory Program

CWA PPL = Clean Water Act priority pollutant list

Koc = partition coefficient of a chemical in the organic matter of soil/sediment

NA = not applicable

O = no

TAL = target analyte list

X = yes

^aSee Table 6

^bPersistence based on evaluation provided in NIH (2010): Chemicals were classified as "persistent" if the Koc value indicated that the chemical was likely to adsorb to suspended solid and sediment. Chemicals were classified as "not persistent" if the Koc value indicated that the chemical may adsorb or was not likely to adsorb to suspended solid and sediment. No additional metrics were used to determine persistence since half-life durations for volatilization from water or biodegradation were very short in comparison to the 44 years that have elapsed since the chemicals were deposited in the impoundment.

Reference: NIH (2010)

Table 8
Summary of Primary and Secondary COPCs

	BHHRA		BERA				
			Benthic Invertebrates		Fish and Wildlife		
COIs	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC	Not a COPC
Dioxins/Furans							
Dioxins and Furans	X				X		
Metals							
Aluminum	X		X				
Antimony							X
Arsenic							X
Barium							X
Cadmium							X
Chromium							X
Cobalt							X
Copper	X		X		X		
Lead							X
Magnesium		X	X				
Manganese							X
Mercury	X		X		X		
Nickel							X
Silver							X
Thallium		X		X			
Vanadium							X
Zinc							X
Semivolatile Organic Compounds							
Acenaphthene							X
Fluorene							X
Naphthalene							X
Phenanthrene							X

Table 8
Summary of Primary and Secondary COPCs

	BHHRA		BERA				
			Benthic Invertebrates		Fish and Wildlife		
COIs	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC	Primary COPC	Secondary COPC	Not a COPC
2,4,6-Trichlorophenol							X
2,4-Dichlorophenol							X
Pentachlorophenol							X
Phenol							X
2,4-Dinitrotoluene							X
2,6-Dinitrotoluene							X
Hexachlorobenzene							X
2,3,4,6-Tetrachlorophenol		X		X			
Carbazole		X		X			
2,4,5-Trichlorophenol							X
Volatile Organic Compound							
Chloroform		X		X			

Notes

BERA = baseline ecological risk assessment
 BHHRA = baseline human health risk assessment
 COI = chemical of interest
 COPC = chemical of potential concern
 X = yes

Table 9
COPC Screening for Human Health

					Background								
	Highest Site Concentration ^a	Frequency of Detection of Site Samples	USEPA Region 3 Soil PRG ³	Highest Background Concentrations (TCEQ and USEPA 2006)	85 th Percentile of Tidal Stream Sediments (TCEQ 2003)	85 th Percentile of NURE HSSR Data (USGS 2009)	Background Comparison Value	Does maximum site value exceed PRG?	Is chemical potentially bioaccumulative from sediment?	Does maximum site value exceed background comparison value?	Is chemical detected at least once in site sediments?	Maintain as COPC for human health?	
Metals (mg/kg)													
Aluminum	22,100	7/7	31	2780	NV	NV	2780	Yes	No	Yes	Yes	Primary	
Antimony	7.2 U	1/7	31	3.8 U	NV	NV	3.8 U	No	No	Yes	Yes	No	
Arsenic	3	4/7	0.39	0.76	8.99	5.3	8.99	Yes	No	No	Yes	No	
Barium	244	7/7	15,000	112	244	608	608	No	No	No	Yes	No	
Cadmium	0.7 U	4/7	70	0.31 U	0.75	NV	0.75	No	Yes	No	Yes	No	
Chromium	22.1	7/7	0.29/120,000	3.9	49	47	49	Yes	No	No	Yes	No	
Cobalt	6.8 J	7/7	23	1.5 J	NV	28	28	No	No	No	Yes	No	
Copper	62.5	7/7	3,100	2.4 J	37.2	28	37.2	No	Yes	Yes	Yes	Primary	
Lead	59.3	7/7	400	2.9	72.3	NV	72.3	No	No	No	Yes	No	
Magnesium	4790	7/7	NV	726	NV	NV	726	NV	No	Yes	Yes	Secondary	
Manganese	790	7/7	1,800	132	NV	1,081	1,081	No	No	No	Yes	No	
Mercury	1.7	7/7	24	0.06 U	0.31	NV	0.31	No	Yes	Yes	Yes	Primary	
Nickel	14	7/7	1,600	2.3 J	23.8	22	23.8	No	Yes	No	Yes	No	
Silver	1.4 U	2/7	390	0.7 U	1.2	NV	1.2	No	No	Yes	Yes	No	
Thallium	3.5 U	0/7	NV	1.6 U	NV	NV	1.6 U	NV	No	Yes	No	Secondary	
Vanadium	34.4	7/7	390	5.3 J	NV	90	90	No	No	No	Yes	No	
Zinc	244	7/7	24,000	11.1	200	364	364	No	Yes	No	Yes	No	
Polychlorinated Biphenyls (µg/kg)													
Total PCBs	90 U	0/7	220	44 U	190	NV	190	No	Yes	No	No	No	
Dioxins/Furans (ng/kg)													
2,3,7,8-TCDD TEQ	24,000	7/7	4.9	3.11	NV	NV	3.11	Yes	Yes	Yes	Yes	Primary	
Semivolatile Organic Compounds (µg/kg)													
Acenaphthene	455 U	0/7	3,400,000	220 U	1,709	NV	1,709	No	No	No	No	No	
Fluorene	455 U	0/7	2,300,000	220 U	1,800	NV	1,800	No	No	No	No	No	
Naphthalene	455 U	0/7	3600	220 U	1,400	NV	1,400	No	No	No	No	No	
Phenanthrene	455 U	0/7	NV	220 U	1,800	NV	1,800	NV	No	No	No	No	
2,4,6-Trichlorophenol	455 U	0/7	44,000	220 U	1,950	NV	1,950	No	No	No	No	No	
2,4-Dichlorophenol	455 U	0/7	180,000	220 U	1,950	NV	1,950	No	No	No	No	No	
Pentachlorophenol	1,150 U	0/7	3,000	550 U	3,850	NV	3,850	No	Yes	No	No	No	
Phenol	455 U	0/7	18,000,000	220 U	1,950	NV	1,950	No	No	No	No	No	
2,4-Dinitrotoluene	455 U	0/7	1,600	220 U	1,800	NV	1,800	No	No	No	No	No	
2,6-Dinitrotoluene	455 U	0/7	61,000	220 U	1,709	NV	1,709	No	No	No	No	No	
Hexachlorobenzene	455 U	0/7	300	220 U	752.7	NV	752.7	Yes	Yes	No	No	No	
2,3,4,6-Tetrachlorophenol	NV	NV	1,800,000	NV	NV	NV	NV	No	No	NV	NV	Secondary	
Carbazole	455 U	0/7	NV	220 U	NV	NV	220 U	NV	No	Yes	No	Secondary	
2,4,5-Trichlorophenol	1,150 U	0/7	6,100,000	550 U	2,050	NV	2,050	No	No	No	No	No	
Volatile Organic Compounds (µg/kg)													
Chloroform	NV	not analyzed	300	NV	300	NV	300	NV	No	NV	NV	Secondary	

Notes

COPC = chemical of potential concern
 NURE HSSR = National Uranium Resource Evaluation program hydrogeochemical and stream sediment reconnaissance
 NV = no value available
 PRG = preliminary remediation goal
 TEQ = toxicity equivalent
 J = estimated
 U = analyte not detected
^aNondetects are provided at 1/2 the detection limit.
^bPRGs are from <http://www.epa.gov/reg3hwmd/risk/human/index.htm>

Table 10
COPC Screening for Benthic Macroinvertebrate Community

				Background Values							
Chemical	NOEC ^a	Highest Site Concentration (TCEQ and USEPA 2006) ^b	Frequency of Detection of Site Samples	Highest Background Concentrations (TCEQ and USEPA 2006) ^b	85 th Percentile of Tidal Stream Sediments (TCEQ 2003)	85 th Percentile of NURE HSSR Data	Background Concentration for Comparison to Site Data ^c	Does Maximum Site Sample Exceed NOEC?	Does Maximum Site Value Exceed Background?	Maintain as COPC for Benthic Invertebrates	Reason for COPC Decision
Metals (mg/kg)											
Aluminum	NV	22,100	7/7	2,780	NV	NV	2,780	NSLV	Yes	Yes	No screening value, detections above background
Antimony	NV	7.2 <i>U</i>	1/7	3.8 <i>U</i>	NV	NV	3.8 <i>U</i>	NSLV	Yes ^d	No	No screening value, variety of DLs with max Site DL > background; however, there is only a single detection in Site data of 2.4 mg/kg (SE-07), below background DL. This is not a chemical expected to be associated with pulp mill waste.
Arsenic	8.2	3	4/7	0.76	8.99	5.3	8.99	No	No	No	Maximum site concentration does not exceed SLV
Barium	NV	244	7/7	112	244	608	608	NSLV	No	No	Maximum site concentration does not exceed regional background
Beryllium	NV	0.7 <i>U</i>	0/7	0.31 <i>U</i>	NV	NV	0.17	NSLV	Yes	Yes (secondary)	No SLV and maximum DL is greater than DL of background, but there are no detected concentrations
Cadmium	1.2	0.7 <i>U</i>	4/7	0.31 <i>U</i>	0.75	NV	0.75	No	No	No	Maximum site concentration does not exceed SLV
Chromium	81	22.1	7/7	3.9	49	47	49	No	No	No	Maximum site concentration does not exceed SLV
Cobalt	NV	6.8 <i>J</i>	7/7	1.5 <i>J</i>	NV	28	28	NSLV	No	No	Maximum site concentration does not exceed regional background
Copper	34	62.5	7/7	2.4 <i>J</i>	37.2	28	37.2	Yes	Yes	Yes	Maximum site concentration exceeds SLV and detections are above background
Lead	46.7	59.3	7/7	2.9	72.3	NV	72.3	No	No	No	Maximum site concentration does not exceed regional background
Magnesium	NV	4,790	7/7	726	NV	NV	726	NSLV	Yes	Yes	No screening value; detections above background.
Manganese	NV	790	7/7	132	NV	1,081	1,081	NSLV	No	No	Maximum site concentration does not exceed regional background
Mercury	0.15	1.7	7/7	0.06 <i>U</i>	0.31	NV	0.31	Yes	Yes	Yes	Maximum site concentration exceeds SLV
Nickel	20.9	14	7/7	2.3 <i>J</i>	23.8	22	23.8	No	No	No	Maximum site concentration does not exceed SLV
Silver	1	1.4 <i>U</i>	2/7	0.7 <i>U</i>	1.2	NV	1.2	Yes	Yes ^d	No	Highest concentration is a non-detect very close to NOEC. High percentage of non-detects. Highest detected concentration is 0.29, below NOEC
Thallium	NV	3.5 <i>U</i>	0/7	1.6 <i>U</i>	NV	NV	1.6 <i>U</i>	NSLV	Yes ^d	Yes (secondary)	No SLV, maximum DL is greater than DL of background, there are no detected concentrations
Vanadium	NV	34.4	7/7	5.3 <i>J</i>	NV	90	90	NSLV	No	No	Maximum site concentration does not exceed regional background
Zinc	150	244	7/7	11.1	200	364	364	Yes	No	No	Maximum site concentration does not exceed regional background
Dioxins/Furans (ng/kg)											
2,3,7,8-TCDD	25,000 ^e	18,500	7/7	0.92	NV	NV	0.92	No	Yes	No	Maximum site value does not exceed SLV
Polychlorinated Biphenyls (PCBs) (µg/kg)											
Total PCBs	1,200 ^f	90 <i>U</i> ^g	0/7	44 <i>U</i> ^g	190	NV	190	N/A	No	No	Highest detection limit does not exceed screening value
Semivolatile Organic Compounds (µg/kg)											
Acenaphthene	16	455 <i>U</i>	0/7	220 <i>U</i>	1,709	NV	1,709	Yes	No	No	Maximum site detection limit does not exceed regional background
Fluorene	19	455 <i>U</i>	0/7	220 <i>U</i>	1,800	NV	1,800	Yes	No	No	Maximum site detection limit does not exceed regional background
Naphthalene	160	455 <i>U</i>	0/7	220 <i>U</i>	1,399.50	NV	1,399.50	Yes	No	No	Maximum site detection limit does not exceed regional background
Phenanthrene	240	455 <i>U</i>	0/7	220 <i>U</i>	1,800	NV	1,800	Yes	No	No	Maximum site detection limit does not exceed regional background
2,4,6-Trichlorophenol	NV	455 <i>U</i>	0/7	220 <i>U</i>	1,950	NV	1,950	NSLV	No	No	Maximum site detection limit does not exceed regional background
2,4-Dichlorophenol	NV	455 <i>U</i>	0/7	220 <i>U</i>	1,950	NV	1,950	NSLV	No	No	Maximum site detection limit does not exceed regional background
Pentachlorophenol	NV	1,150 <i>U</i>	0/7	550 <i>U</i>	3,850	NV	3,850	NSLV	No	No	Maximum site detection limit does not exceed regional background
Phenol	NV	455 <i>U</i>	0/7	220 <i>U</i>	1,950	NV	1,950	NSLV	No	No	Maximum site detection limit does not exceed regional background

Table 10
COPC Screening for Benthic Macroinvertebrate Community

				Background Values							
Chemical	NOEC ^a	Highest Site Concentration (TCEQ and USEPA 2006) ^b	Frequency of Detection of Site Samples	Highest Background Concentrations (TCEQ and USEPA 2006) ^b	85 th Percentile of Tidal Stream Sediments (TCEQ 2003)	85 th Percentile of NURE HSSR Data	Background Concentration for Comparison to Site Data ^c	Does Maximum Site Sample Exceed NOEC?	Does Maximum Site Value Exceed Background?	Maintain as COPC for Benthic Invertebrates	Reason for COPC Decision
2,4-Dinitrotoluene	NV	455 <i>U</i>	0/7	220 <i>U</i>	1,800	NV	1,800	NSLV	No	No	Maximum site detection limit does not exceed regional background
2,6-Dinitrotoluene	NV	455 <i>U</i>	0/7	220 <i>U</i>	1,709	NV	1,709	NSLV	No	No	Maximum site detection limit does not exceed regional background
Hexachlorobenzene	NV	455 <i>U</i>	0/7	220 <i>U</i>	752.7	NV	752.7	NSLV	No	No	Maximum site detection limit does not exceed regional background
2,3,4,6-Tetrachlorophenol	NV	NV	NV	ND	NV	NV	NV	NA	NA	Yes (secondary)	No information available on which to base evaluation
Carbazole	NV	455 <i>U</i>	0/7	220 <i>U</i>	NV	NV	220 <i>U</i>	NSLV	Yes	Yes (secondary)	No SLV, maximum DL is greater than DL of background, there are no detected concentrations
2,4,5-Trichlorophenol	NV	1,150 <i>U</i>	0/7	550 <i>U</i>	2,050	NV	2,050	NSLV	No	No	Maximum site detection limit does not exceed regional background
Volatile Organic Compounds (µg/kg)											
Chloroform	4300 ^d	NV	NV	NV	300	NV	300	NA	NV	Yes (secondary)	No information available on which to base evaluation

Notes

DL = detection limit

EqP = equilibrium partitioning

OC = organic carbon

NOEC = no effect concentration

NV = no value

NSLV=no screening level value available

NURE HSSR = National Uranium Resource Evaluation program hydrogeochemical and stream sediment reconnaissance

SLV= screening level value

J = estimated

U = analyte not detected

^aNOEC (no effect concentration) is from Long et al. (1995) unless otherwise indicated. Units of screening value match those of sediment data as given in compound class header (e.g., metals in mg/kg)

^bNondetects are provided at 1/2 the detection limit.

^cThe highest of the three background data set concentrations is selected unless a non-detect is the highest value and there are detected background values available. In that case, the non-detect value is ignored and the next-highest detection value is chosen. This approach reduces the possibility that a comparison is made to an elevated detection limit, which may not be representative of actual data.

^dComparison is uncertain because there is a high percentage of non-detects for chemical at site and a maximum detection limit is being used.

^eBarber et al. (1998)

^fFuchsman et al. (2006). Lowest unbounded NOEC (growth) for a PCB mixture of 81 mg/kg OC (*Macoma nasuta*). Using EqP and conservative estimate of organic carbon of 1.5 percent (Louchouart and Brinkmeyer 2009), the dry weight equivalent of this value is 1.2 mg/kg.

^gAs there were no detections of PCBs, this value is the highest reporting limit in the data set for PCBs

^hTable 3-3 in TCEQ and USEPA (2006)

Table 11
COPC Screening for Fish and Wildlife

			Background Values									
Chemical	Highest Site Concentration (TCEQ and USEPA 2006) ¹	Frequency of Detection of Site Samples	Highest Background Concentrations (TCEQ and USEPA 2006) ²	85 th Percentile of NURE HSSR data	85 th Percentile of Tidal Stream Sediments (TCEQ 2003)	Background Concentration for Comparison to Site Datab	Log Kow of Chemical (Organics Only) ³	Is Chemical Potentially Bioaccumulative from Sediment? ^{2f}	Does Maximum Site Value Exceed Background?	Does Chemical Have Potential to Bioaccumulate? ^{2g}	Maintain as COPC for Fish and Wildlife	Reason for COPC Decision
Metals (mg/kg)												
Aluminum	22,100	7/7	2,780	NV	NV	2,780	NA	No	Yes		No	Not potentially bioaccumulative
Antimony	7.2 U	1/7	3.8 U	NV	NV	3.8 U	NA	No	Yes ⁶	No	No	Not potentially bioaccumulative
Arsenic	3	7/7	0.76	5.3	8.99	8.99	NA	No	No	No	No	Not potentially bioaccumulative
Barium	244	7/7	112	608	244	608	NA	No	No		No	Not potentially bioaccumulative
Cadmium	0.7 U	4/7	0.31 U	NV	0.75	0.75	NA	Yes	No	Yes	No	Concentrations are not above background
Chromium	22.1	7/7	3.9	47	49	49	NA	No	No	No	No	Not potentially bioaccumulative
Cobalt	6.8 J	7/7	1.5 J	28	NV	28	NA	No	Yes		No	Not potentially bioaccumulative
Copper	62.5	7/7	2.4 J	28	37.2	37.2	NA	Yes	Yes	Yes	Yes	Potentially bioaccumulative, detected, and above background concentrations
Lead	59.3	7/7	2.9	NV	72.3	72.3	NA	No	Yes	No	No	Not potentially bioaccumulative
Magnesium	4,790	7/7	726	NV	NV	726	NA	No	Yes		No	Not potentially bioaccumulative
Manganese	790	7/7	132	1,081	N V	1,081	NA	No	Yes		No	Not potentially bioaccumulative
Mercury	1.7	7/7	0.06 U	NV	0.31	0.31	NA	Yes	Yes	Yes	Yes	Potentially bioaccumulative, detected, and above background concentrations
Nickel	14	7/7	2.3 J	22	23.8	23.8	NA	Yes	No	Yes	No	Concentrations are not above background
Silver	1.4 U	2/7	0.7 U	NV	1.17	1.2	NA	No	Yes ⁶	No	No	Not potentially bioaccumulative
Thallium	3.5 U	0/7	1.6 U	NV	N V	1.6 U	NA	No	Yes ⁶	No	No	Not potentially bioaccumulative
Vanadium	34.4	7/7	5.3 J	90	N V	90	NA	No	Yes		No	Not potentially bioaccumulative
Zinc	244	7/7	11.1	364	200	364	NA	Yes	No	Yes	No	Concentrations are not above NURE HSSR background
Dioxins/Furans (ng/kg)												
TEQ birds at ND=1/2DL	62,200	N/A	4.87	NV	NV	4.87	>5	Yes	Yes		Yes	Potentially bioaccumulative, detected, and above background concentrations
TEQ fish at ND=1/2DL	22,300	N/A	3.14	NV	NV	3.14	>5	Yes	Yes		Yes	Potentially bioaccumulative, detected, and above background concentrations
TEQ mammals at ND=1/2 DL	24,000	N/A	3.11	NV	NV	3.11	>5	Yes	Yes		Yes	Potentially bioaccumulative, detected, and above background concentrations
Polychlorinated Biphenyls (ug/kg)												
Total PCBs	90 U ⁸	0/7	44 U ⁸	NV	190	190	>5	Yes	No		No	Concentrations are not above regional background
Semivolatile Organic Compounds (ug/kg)												
Acenaphthene	455 U	0/7	220 U	NV	1,709	1,709	3.92	No ¹	No		No	Not potentially bioaccumulative
Fluorene	455 U	0/7	220 U	NV	1,800	1,800	4.18	No ¹	No		No	Not potentially bioaccumulative
Naphthalene	455 U	0/7	220 U	NV	1,399.5	1,399.5	3.3	No ¹	No		No	Not potentially bioaccumulative
Phenanthrene	455 U	0/7	220 U	NV	1,800	1,800	4.57	No ¹	No		No	Not potentially bioaccumulative
2,4,6-Trichlorophenol	455 U	0/7	220 U	NV	1,950	1,950	3.72	No ¹	No		No	Not potentially bioaccumulative
2,4-Dichlorophenol	455 U	0/7	220 U	NV	1,950	1,950	3.06	No ¹	No		No	Not potentially bioaccumulative
Pentachlorophenol	1,150 U	0/7	550 U	NV	3,850	3,850	5.12	Yes	No		No	Concentrations are not above background
Phenol	455 U	0/7	220 U	NV	1,950	1,950	1.46	No ¹	No		No	Not potentially bioaccumulative
2,4-Dinitrotoluene	455 U	0/7	220 U	NV	1,800	1,800	1.98	No ¹	No		No	Not potentially bioaccumulative
2,6-Dinitrotoluene	455 U	0/7	220 U	NV	1709	1,709	2.1	No ¹	No		No	Not potentially bioaccumulative
Hexachlorobenzene	455 U	0/7	220 U	NV	752.7	752.7	5.73	Yes	No		No	Concentrations are not above background
2,3,4,6-Tetrachlorophenol	NV	NV	NV	NV	NV	NV	4.45	No ¹	NV		No	Not potentially bioaccumulative
Carbazole	455 U	0/7	220 U	NV	NV	220 U	3.72	No ¹	Yes ⁶		No	Not potentially bioaccumulative
2,4,5-Trichlorophenol	1,150 U	0/7	550 U	NV	2,050	2,050	3.69	No ¹	No		No	Not potentially bioaccumulative
Volatile Organic Compounds (ug/kg)												
Chloroform	NV	NV	NV	NV	300	300	1.97	No ¹	N/A		No	Not potentially bioaccumulative

Notes

COPC = chemical of potential concern

NA = not applicable

NURE HSSR = National Uranium Resource Evaluation program hydrogeochemical and stream sediment reconnaissance

NV = no value

TCEQ = Texas Commission on Environmental Quality

TEQ = toxicity equivalent

J = estimated

U = analyte not detected

²Undetected values are set to 1/2 the detection limit.

³The highest of the three background dataset concentrations is selected unless a non-detect is the highest value and there are detected background values are available. In that case, the non-detect value is ignored and the next-highest detection value is chosen.

This approach reduces the possibility that a comparison is made to an elevated detection limit, which may not be representative of actual data.

⁴ Log Kow: Octanol-water partition coefficient, the ratio of the concentration of a chemical in octanol and water at equilibrium and at a specified temperature. Octanol is an organic solvent that is used as a surrogate for natural organic matter (e.g., lipids).

Values obtained from the HSDB (<http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB>)

or Oak Ridge National Laboratory Risk Assessment Information System (http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=chem)

⁵Determination of bioaccumulative potential is based on TCEQ guidance (TCEQ 2006) or, if chemical is not addressed in guidance, log Kow information is used to determine bioaccumulative potential (as indicated in footnote e), with those chemicals having log Kow>5 being considered potentially bioaccumulative (USEPA 2008).

⁶Comparison is uncertain because there is a high percentage of non-detects for chemical at site and a maximum detection limit is being used.

⁷Not provided in TCEQ guidance; log Kow used to determine potential for bioaccumulation as described in footnote d.

⁸As there were no detections of PCBs, this value is the highest reporting limit in the dataset for PCBs

Table 12
Physical Testing Data Relevant to Dredging, Materials Handling, and/or Confined Disposal Facility (CDF) Design

	Engineering Evaluations Testing										
	Standard Penetration Test (ASTM D-1586)	Thin-Walled Tube Sample Collection (ASTM D-1587)	Vane Shear Test (ASTM D-2573)	Atterberg Limits (ASTM D-4318)	Grain Size (ASTM D-422 & D-1140)	Specific Gravity (ASTM D-854)	Moisture Content (ASMT D-2216)	Visual Description (ASMT D-2488)	Permeability (ASTM D-5084)	Consolidated Undrained Triaxial Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)
Dredging and Handling											
Hydraulic Dredging and Materials Handling	--	--	--	X	X	X	X	X	--	--	--
CDF and Berm Design											
Soil Classification	X	X	--	X	X	X	X	X	X	--	--
Soil Strength	X	X	X	--	--	--	--	--	--	X	--
Soil Compressibility	--	X	--	--	--	--	--	--	--	--	X

Notes

-- = NA

CDF = confined disposal facility

X = yes

Table 13
Number of Locations Sampled^a

Sample Group	Sampling Method and Depth	Number of Locations	Sample Locations	Analytes	Study Elements
Site surface sediment, primary COPCs	Grab sampler, surface 10 cm (0-4 in.)	52 ^b	152-m (500-ft) grid within 305 to 457 m (1,000 to 1,500 ft) of the waste pit and Big Star property, 305-m (1,000-ft) grid elsewhere	Primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived.	Nature and extent, ecological exposure, fate and transport
Impoundment characterization sample	Grab sampler, surface 10 cm (0-4 in.)	5	Within the impoundment area	1 station for primary and secondary COPCs, organic carbon, grain size, and solids; 4 stations for primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived at these 4 stations.	Nature and extent, characterization of waste materials
Site surface sediment, all COPCs	Grab sampler, surface 10 cm (0-4 in.)	11	Selected locations on a 152-m (500-ft) grid within approximately 305 m (1,000 ft) of the waste pit (coincident with core locations)	Primary and secondary COPCs, organic carbon, grain size, solids, and specific gravity	Nature and extent, ecological exposure, fate and transport
Site subsurface sediment	Cores to refusal or maximum depth of 3 m (10 ft), sectioned at 30-cm (1-ft) intervals	10	Selected locations on a 152-m (500-ft) grid within approximately 305 m (1,000 ft) of the waste pit	Primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived. (Atterberg limits and specific gravity at all core locations)	Nature and extent, dredging assessment
Shoreline sediment for human health risk assessment	Surface 0-15 cm (0-6 in.) and subsurface 15-30 cm (6-12 in.)	30	Ten per beach on three beaches	5 surface sediment samples from each of the exposure areas and the corresponding subsurface sediment samples from the eastern shoreline of the Big Star property will be analyzed initially for primary COPCs. The remaining 5 surface samples from each area, 5 subsurface samples from the eastern shoreline of the Big Star property, and all 10 subsurface samples from the other two exposure areas will be archived.	Exposure for human health risk assessment
Shoreline sediment for ecological risk assessment	Grab sampler, surface 10 cm (0-4 in.)	9	Three in each of three locations where ecological exposures are anticipated	Primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived.	Exposure for ecological risk assessment
Upstream background surface samples	Grab sampler, surface 10 cm (0-4 in.)	11	Upstream in San Jacinto River on four transverse transects	Primary and secondary COPCs, organic carbon, grain size, solids, and specific gravity	Nature and extent, ecological exposure, fate and transport
Upstream shoreline sediment for human health risk assessment	Surface 1-15 cm (0-6 in.) and subsurface 15-30 cm (6-12 in.)	10	Ten per beach on one beach	Primary COPCs, organic carbon, grain size, and solids on 5 surface samples. Remainder of surface samples and all of the subsurface samples will be archived.	Exposure for human health risk assessment
Upstream shoreline sediment for ecological risk assessment	Grab sampler, surface 10 cm (0-4 in.)	3	Three on one beach where ecological exposures are anticipated	Primary COPCs, organic carbon, grain size, solids, and specific gravity. Sediment for analysis of secondary COPCs will be archived.	Exposure for ecological risk assessment
Soil borings in the impoundment and berm	Various depths depending on location	9	In areas of berm reconstruction and in the impoundment area.	Atterberg limits, specific gravity, soil strength, soil permeability, and soil compressibility	CDF design
Vane shear tests in the impoundment and berm	Surface	6	In areas of berm reconstruction and in the impoundment area	Vane shear and triaxial tests	CDF design

Notes

CDF = confined disposal facility

COPC = chemical of potential concern

^a Numbers do not include field quality control samples, and cores, which generate more than one "sample," are counted only once.

^b Numbers include all Site surface samples for primary COPCs for nature and extent evaluations (48 locations) and surface sediment samples to characterize the impoundment (4 locations)

Table 14
Soil Boring Geotechnical Sampling Design

Sample ID	Depth Interval ^a (ft)	SPT-N	Moisture Content	Grain Size ^b	Atterberg Limits ^b	Specific Gravity ^b	Permeability ^{b,c}	CuTriax ^{b,c}	Consolidation ^{b,c}
Locations SJGB003 and SJGB007: 120-ft deep boring (in-water geotech location)									
S1	0-1.5	X	X	--	--	--	--	--	--
S2	2.5 - 4.0	X	X	X	--	--	--	--	--
S3	5.0 - 7.0	--	X	--	X	--	--	X	X
S4	7.5 - 9.0	X	X	--	--	--	--	--	--
S5	10.0 - 11.5	X	X	--	X	X	--	--	--
S6	15.0 - 16.5	X	X	X	--	--	--	--	--
S7	20.0 - 21.5	X	X	--	--	--	--	--	--
S8	25.0 - 26.5	X	X	--	X	--	--	--	--
S9	30.0 - 31.5	X	X	X	--	--	--	--	--
S10	35.0 - 36.5	X	X	--	--	--	--	--	--
S11	40.0 - 42.0	--	X	--	X	--	--	--	X
S12	45.0 - 46.5	X	X	X	--	--	--	--	--
S13	50.0 - 51.5	X	X	--	--	--	--	--	--
S14	55.0 - 56.5	X	X	--	X	X	--	--	--
S15	60.0 - 61.5	X	X	X	--	--	--	--	--
S16	65.0 - 66.5	X	X	--	X	--	--	--	--
S17	70.0 - 71.5	X	X	--	X	X	--	--	--
S18	75.0 - 76.5	X	X	X	--	--	--	--	--
S19	80.0 - 81.5	X	X	--	--	--	--	--	--
S20	85.0 - 86.5	X	X	--	X	--	--	--	--
S21	90.0 - 91.5	X	X	X	--	--	--	--	--
S22	95.0 - 96.5	X	X	--	--	--	--	--	--
S23	100.0 - 101.5	X	X	--	X	--	--	--	--
S24	105.0 - 106.5	X	X	X	--	--	--	--	--
S25	110.0 - 111.5	X	X	--	--	--	--	--	--
S26	115.0 - 116.5	X	X	--	X	X	--	--	--
S27	120.0 - 121.5	X	X	X	--	--	--	--	--
Locations SJGB001, SJGB002, SJGB004, SJGB005, and SJGB008: 60-ft deep boring (in-water/on-land geotech location)									
S1	0-1.5	X	X	--	--	--	--	--	--
S2	2.5 - 4.0	X	X	X	--	--	--	--	--
S3	5.0 - 7.0	--	X	--	X	--	--	X	X

Table 14
Soil Boring Geotechnical Sampling Design

Sample ID	Depth Interval ^a (ft)	SPT-N	Moisture Content	Grain Size ^b	Atterberg Limits ^b	Specific Gravity ^b	Permeability ^{b,c}	CuTriax ^{b,c}	Consolidation ^{b,c}
S4	7.5 - 9.0	X	X	--	--	--	--	--	--
S5	10.0 - 11.5	X	X	--	X	X	--	--	--
S6	15.0 - 16.5	X	X	X	--	--	--	--	--
S7	20.0 - 21.5	X	X	--	--	--	--	--	--
S8	25.0 - 26.5	X	X	--	X	--	--	--	--
S9	30.0 - 31.5	X	X	X	--	--	--	--	--
S10	35.0 - 36.5	X	X	--	--	--	--	--	--
S11	40.0 - 41.5	--	X	--	X	--	--	--	X
S12	45.0 - 46.5	X	X	X	--	--	--	--	--
S13	50.0 - 51.5	X	X	--	--	--	--	--	--
S14	55.0 - 56.5	X	X	--	X	X	--	--	--
S15	60.0 - 61.5	X	X	X	--	--	--	--	--
Locations SJGB006 and SJGB009: 30-ft deep boring (former waste pit geotech location)									
S1	0-1.5	X	X	--	--	--	--	--	--
S2	2.5 - 4.0	--	X	X	X	--	X	--	--
S3	5.0 - 7.0	--	X	--	--	--	--	X	X
S4	7.5 - 9.0	--	X	--	X	--	X	--	--
S5	10.0 - 11.5	X	X	--	X	X	--	--	--
S6	15.0 - 16.5	X	X	X	--	--	--	--	--
S7	20.0 - 21.5	X	X	--	--	--	--	--	--
S8	25.0 - 26.5	X	X	--	X	--	--	--	--
S9	30.0 - 31.5	X	X	X	--	--	--	--	--

Notes

-- = NA

CuTriax = consolidated, undrained triaxial test

SPT-N = standard penetration test blow counts

X = yes

^aDepth interval will be set in the field depending on the starting depth of the auger. All depths relative to ground surface or mudline.

^bActual physical testing depth interval will be determined in the field based on the geologic interpretation of conditions encountered.

^cPermeability, CuTriax and consolidation testing to be performed on undisturbed Shelby tubes collected from appropriate depth intervals in the field as determined by the field geologist.

Table 15
Vane Shear Test and Co-Located Surface Grab Sampling Design

Station ID	Proposed Coordinates ^{a,b}	Sample Method	Sampling Depth (ft) ^{c,d}	Sample Method	Sampling Depth (ft) ^e	Physical Tests
SJ-VST01	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST02	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST03	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST04	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST05	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST06	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG

Notes

Sediment surface grabs will be co-located with VST locations to facilitate standardization of the field vane shear measurements.

TBD = to be determined

VST = vane shear test

^aCoordinates will be determined based on finalization of sampling locations.

^bPhysical testing: GS = grain size, MC = moisture content, AL = Atterberg limits, SG = specific gravity

^cVST to be performed at the following depth intervals below mudline: 0-1, 1-2, and 2-3 ft.

^dBoth peak and residual VST strength to be measured at each depth interval.

^eSample depth refers to surface grabs, not to the VST depth.

Table 16
Sample Containers, Preservation, and Holding Time Requirements

Matrix	Container ^a		Laboratory	Parameter	Preservation	Holding Time	Sample Size ^b
	Type	Size					
Sediment							
	WMG	8 oz.	TBD	Percent moisture (EPA 160.3)	4±2°C	6 months	10 g
				TOC	4±2°C	28 days	1 g
				Metals	4±2°C	6 months	10 g
				Mercury	4±2°C	28 days	5 g
	WMG	16 oz.	TBD	Grain size	4±2°C	6 months	100 g
	WMG	8 oz.	TBD	Atterberg limits	4±2°C	NA	225 g
				Percent moisture (ASTM D 2216)	4±2°C	6 months	10 g
				Specific gravity	4±2°C	NA	
	WMG	8 oz.	TBD	Dioxins/furans	4±2°C/Deep frozen (-20°C) ^c / -10°C ^d	1 year/1 year ^e	50 g
	WMG	8 oz.	TBD	Semivolatile organic compound	4±2°C	14 days/40 days ^e	50 g
	WMG	2 oz.	TBD	Volatile organic compound	4±2°C; do not freeze	14 days	5 g
	WMG	8 oz.	NA	Archival	4±2°C/ Deep frozen (-20°C) ^c	NA	N/A
	Thin wall sampler	--	TBD	Sediment permeability	Airtight seal	6 months ^f	N/A
	Thin wall sampler	--	TBD	Consolidated undrained triaxial compressive strength	Airtight seal	6 months ^f	N/A
	Thin wall sampler	--	TBD	Sediment compressibility	Airtight seal	6 months ^f	N/A
Equipment Filter Wipe Blanks							
	HDPE	4 oz.	TBD	Metals	4±2°C	6 months	1 wipe
	HDPE	4 oz.	TBD	Mercury	4±2°C	28 Days	2 wipe
	AG	4 oz.	TBD	Dioxins/furans	4±2°C	1 year/1 year ^e	3 wipe
	AG	4 oz.	TBD	Semivolatile organic compound	4±2°C	7 days/40 days ^e	4 wipe

Notes

AG = amber glass

HDPE = high density polyethylene

NA = not applicable

TBD = to be determined

WMG = wide mouth glass

^a The size and number of containers may be modified by the analytical laboratory.

^b Sample sizes may be modified one laboratory selection is made.

^c Samples will be shipped to the laboratory on ice at 4±2°C. Once received at the laboratory, samples will be stored at -20°C.

^d Extracts will be stored at -10°C.

^e Holding time for samples prior to extraction/ holding time for extracts.

^f Published holding time does not exist. Holding time shown is based on best professional judgment

Table 17
Proposed Laboratory Methods for Sediment Samples

Matrix	Parameter	Laboratory	Sample Preparation		Quantitative Analysis	
			Protocol	Procedure	Protocol	Procedure
Sediment	<i>Conventional and Geotechnical</i>					
	Percent moisture (nature & extent samples)	TBD	EPA 160.3	Oven drying	EPA 160.3	Balance/gravimetric
	Percent moisture (geotechnical borings)	TBD	ASTM D 2216	Oven drying	ASTM D 2216	Balance/gravimetric
	Total organic carbon	TBD	EPA 9060A	Acid pretreatment	EPA 9060A (modified for sediment)	Combustion
	Grain size	TBD	NA	--	ASTM D-422 & D-1140 with PSEP (1986) modifications	Sieves and pipette method
	Atterberg limits	TBD	NA	--	ASTM D-4318-00	Wet method; moisture determination
	Specific gravity	TBD	NA	--	ASTM D-854-02	Water pycnometer
	Sediment compressibility	TBD	NA	NA	ASTM D-2435	One-dimensional consolidation
	Sediment permeability	TBD	NA	NA	ASTM D-5084 (fine grained samples) / ASTM D-2434 (coarse grained samples)	Flexible wall permeameter (D-5084) / rigid wall permeameter (D-2434)
	Consolidated undrained triaxial compressive strength	TBD	NA	NA	ASTM D-4767	Isotropic consolidation; shearing in compression

Table 17
Proposed Laboratory Methods for Sediment Samples

Matrix	Parameter	Laboratory	Sample Preparation		Quantitative Analysis	
			Protocol	Procedure	Protocol	Procedure
	Metals					
	aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, vanadium, zinc	TBD	EPA 3050	Strong acid digestion	EPA 6010B/6020	ICP/ICP/MS
	Mercury	TBD	EPA 7471A	Acid digestion/oxidation	EPA 7471A	CVAA
	Organics					
	Dioxins /furans	TBD	EPA 1613B/8290A	Soxhlet extraction	EPA 1613B/8290A	HRGC/HRMS
				Silica gel column cleanup		
				Additional cleanup as needed		
	SVOCs	TBD	EPA 3540C / 3541 / 3545A	Soxhlet / automated Soxhlet / pressurized fluid extraction	EPA 8270C	GC/MS
			EPA 3640A	Gel permeation chromatography		
	VOCs	TBD	EPA 5035	Purge and trap	EPA 8260B	GC/MS

Notes

ASTM = American Society for Testing and Materials
CVAA = cold vapor atomic absorption spectrometry
EPA = U.S. Environmental Protection Agency
GC/MS = gas chromatography/mass spectrometry
HRGC = high-resolution gas chromatography
HRMS = high-resolution mass spectrometry
ICP = inductively coupled plasma-atomic emission spectrometry

ICP/MS = inductively coupled plasma/mass spectrometry
NA = not applicable
ORNL = Oak Ridge National Laboratory
PSEP = Puget Sound Estuary Program
SVOC = semivolatile organic compound
TBD = to be determined

Table 18
Analytes, Analytical Concentration Goals (ACG), Method Reporting Limits (MRL), and Method Detection Limits (MDL) for Sediment Samples

Analyte	CAS number	HHRA ACG	BERA ACG	MRL	MDL
Conventionals					
Percent moisture (percent)	--	NA	NA	TBD	N/A
Total organic carbon (percent)	--	NA	NA	TBD	TBD
Grain size (percent retained)	--	NA	NA	TBD	N/A
Atterberg limits (percent moisture)	--	NA	NA	TBD	N/A
Specific gravity (unitless)	--	NA	NA	TBD	N/A
Metals (mg/kg-dry weight)					
Aluminum	7429-90-5	31	2,780	TBD	TBD
Copper	7440-50-8	3,100	2.4	TBD	TBD
Magnesium	7439-95-4	726	726	TBD	TBD
Thallium	7440-28-0	1.6	1.6	TBD	TBD
Mercury	7439-97-6	24	0.06	TBD	TBD
Organics					
Dioxins/furans (ng/kg-dry weight)					
1,2,3,4,6,7,8-Heptachlorodibenzo- <i>p</i> -dioxin	35822-46-9	NA	NA	TBD	TBD
1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	NA	NA	TBD	TBD
1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	NA	NA	TBD	TBD
1,2,3,4,7,8-Hexachlorodibenzo- <i>p</i> -dioxin	39227-28-6	NA	NA	TBD	TBD
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	NA	NA	TBD	TBD
1,2,3,6,7,8-Hexachlorodibenzo- <i>p</i> -dioxin	57653-85-7	NA	NA	TBD	TBD
1,2,3,6,7,8-Hexachlorodibenzofuran	57117-44-9	NA	NA	TBD	TBD
1,2,3,7,8,9-Hexachlorodibenzo- <i>p</i> -dioxin	19408-74-3	NA	NA	TBD	TBD
1,2,3,7,8,9-Hexachlorodibenzofuran	72918-21-9	NA	NA	TBD	TBD
1,2,3,7,8-Pentachlorodibenzofuran	57117-41-6	NA	NA	TBD	TBD
1,2,3,7,8-Pentachlorodibenzo- <i>p</i> -dioxin	40321-76-4	NA	NA	TBD	TBD
2,3,4,6,7,8-Hexachlorodibenzofuran	60851-34-5	NA	NA	TBD	TBD
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	NA	NA	TBD	TBD

Table 18
Analytes, Analytical Concentration Goals (ACG), Method Reporting Limits (MRL), and Method Detection Limits (MDL) for Sediment Samples

Analyte	CAS number	HHRA ACG	BERA ACG	MRL	MDL
2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin	1746-01-6	NA	NA	TBD	TBD
2,3,7,8-Tetrachlorodibenzofuran	51207-31-9	NA	NA	TBD	TBD
Octachlorodibenzo- <i>p</i> -dioxin	3268-87-9	NA	NA	TBD	TBD
Octachlorodibenzofuran	39001-02-0	NA	NA	TBD	TBD
total tetrachlorinated dioxins	41903-57-5	NA	NA	NA	NA
total pentachlorinated dioxins	36088-22-9	NA	NA	NA	NA
total hexachlorinated dioxins	34465-46-8	NA	NA	NA	NA
total heptachlorinated dioxins	37871-00-4	NA	NA	NA	NA
total tetrachlorinated furans	30402-14-3	NA	NA	NA	NA
total pentachlorinated furans	30402-15-4	NA	NA	NA	NA
total hexachlorinated furans	55684-94-1	NA	NA	NA	NA
total heptachlorinated furans	38998-75-3	NA	NA	NA	NA
2,3,7,8-TCDD TEQ fish	NA	NA	3.14	NA	NA
2,3,7,8-TCDD TEQ bird	NA	NA	4.9	NA	NA
2,3,7,8-TCDD TEQ mammal	NA	4.9	3.11	NA	NA
Semivolatile Organic Compounds (µg/kg-dry weight)					
Carbazole	86-74-8	220	550	TBD	TBD
2,3,4,6-Tetrachlorophenol	58-90-2	1,800,000	NV	TBD	TBD
Volatile Organic Compounds (µg/kg-dry weight)					
Chloroform	67-66-3	300	300	TBD	TBD

Notes

BERA = baseline ecological risk assessment

HHRA = human health risk assessment

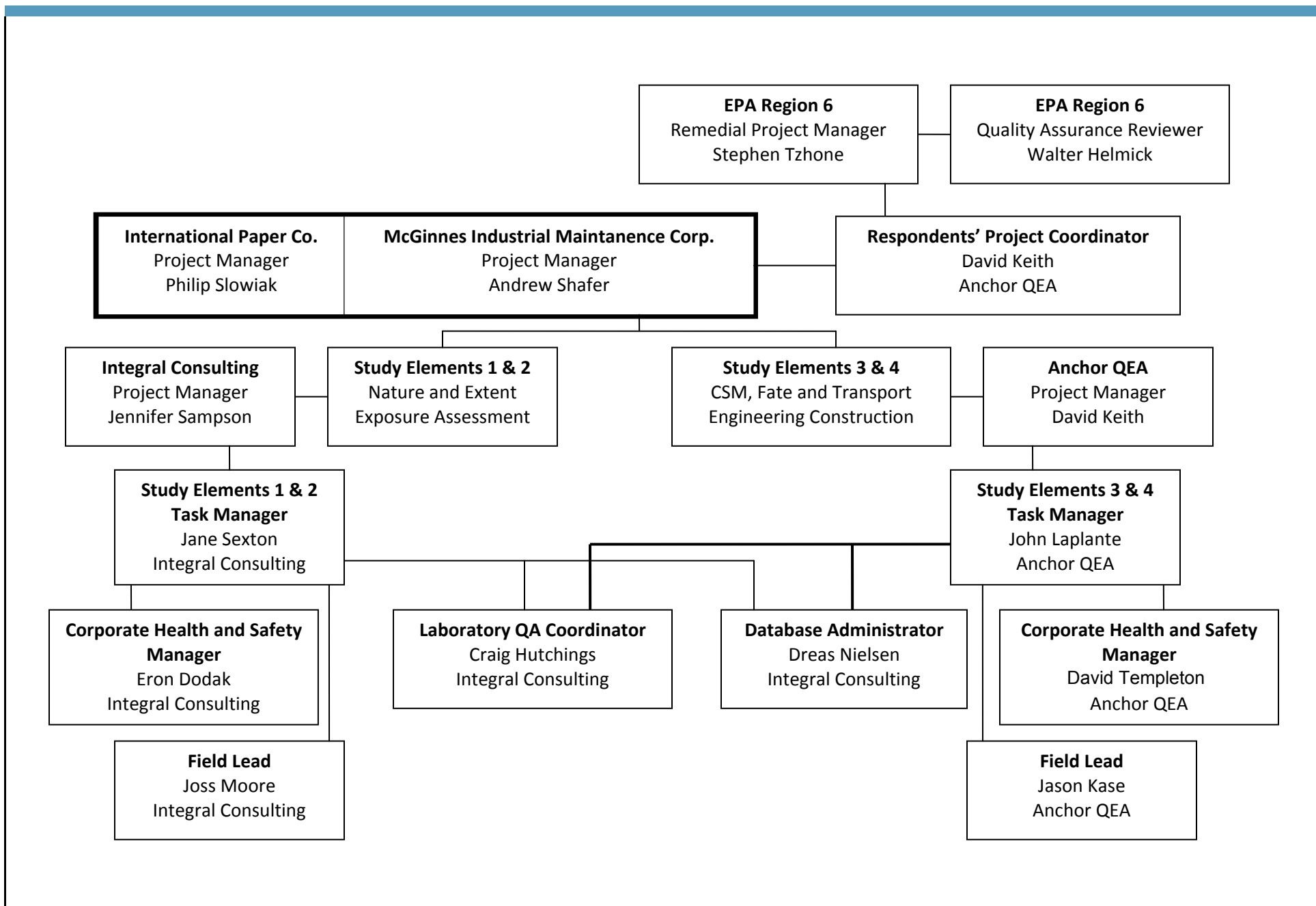
NA = not applicable

NV = no value

TBD = to be determined

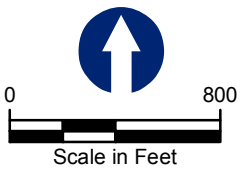
TEQ = toxicity equivalent

FIGURES





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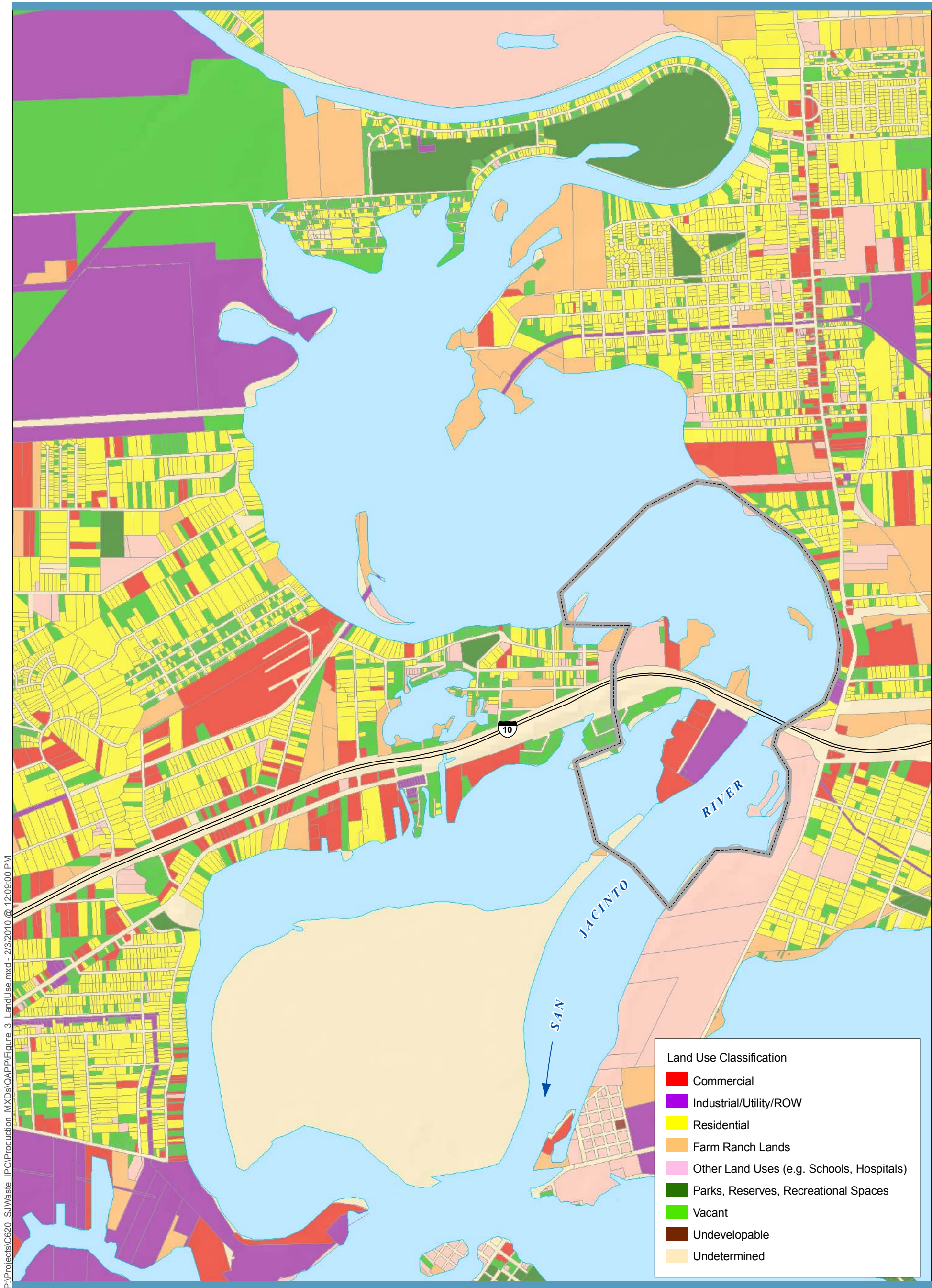


- Preliminary Site Perimeter
- Upland Sand Separation Area
- Current Perimeter of Impoundments
- Original Perimeter of Impoundments

FEATURE SOURCES:
Aerial Imagery: 0.5-meter January 2009 DOQQs - Texas Strategic Mapping Program (StratMap),

Figure 2
Overview of Current Site
SJRWP Sediment QAPP
SJRWP Superfund/MIMC and IPC

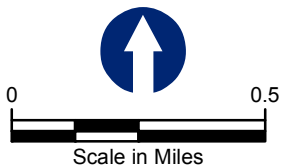
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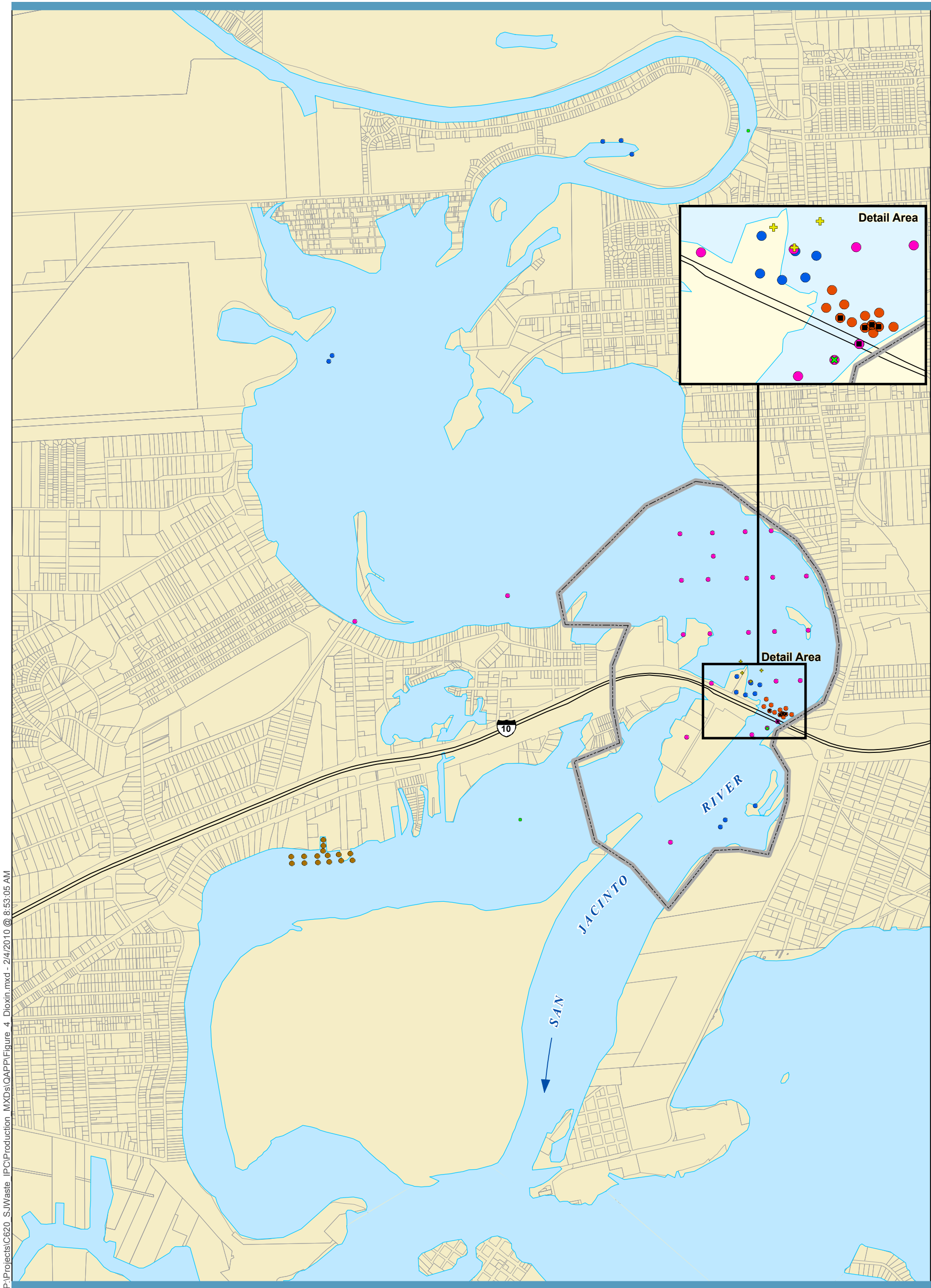
Preliminary Site Perimeter
 Parcel Boundary



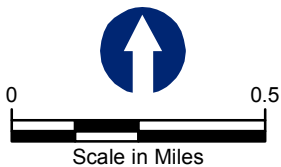
FEATURE SOURCES:
 Zoning: Houston-Galveston Area Council
 Parcel Boundaries: Harris County Appraisal District

Figure 3
 Land Use
 SJRWP Sediment QAPP
 SJRWP Superfund/MIMC and IPC

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FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

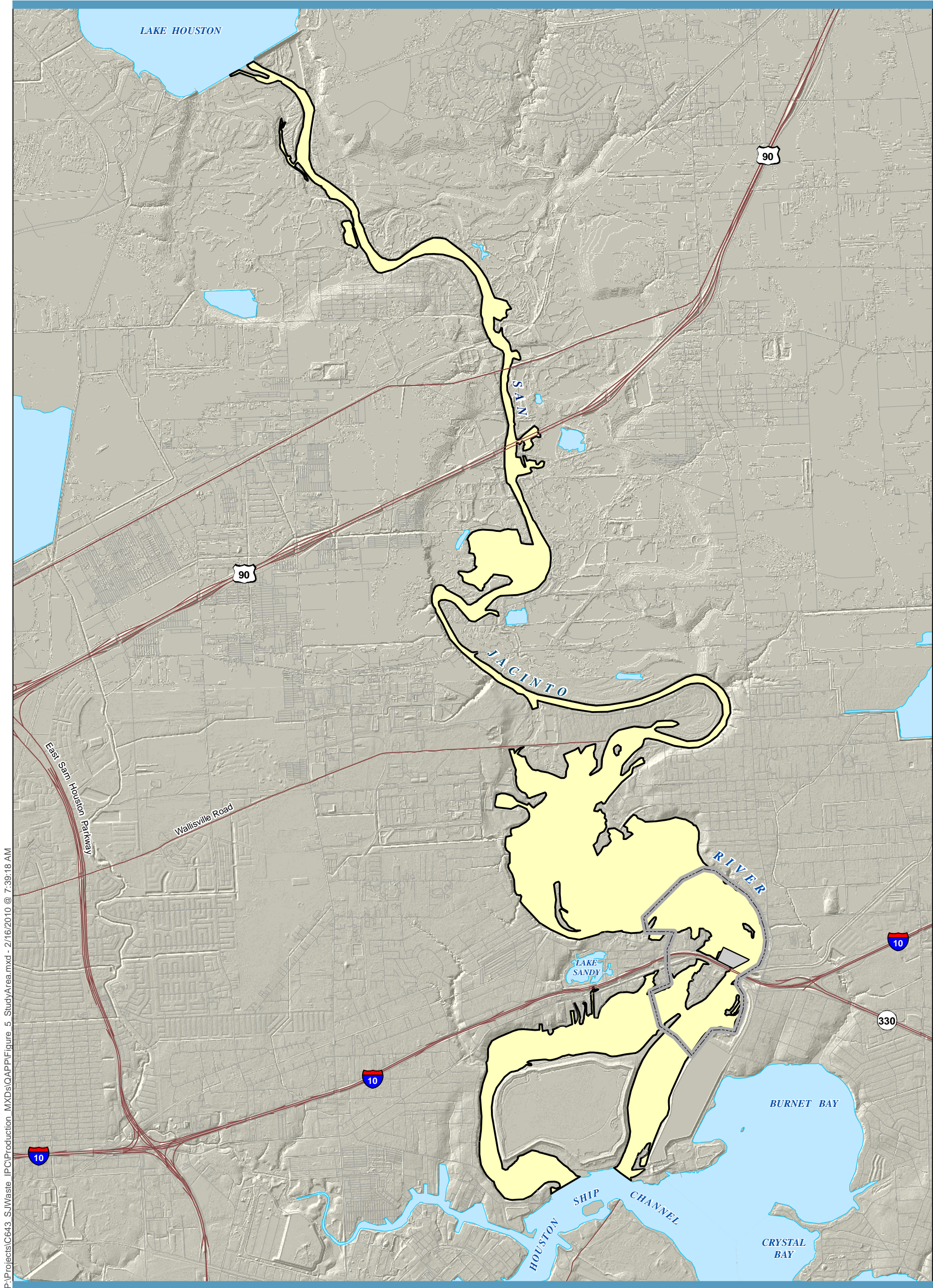
- Preliminary Site Perimeter
- Parcel Boundary

- Dioxin/Furans Surface Sample**
- ENSR and EHA (1995)
 - TCEQ and USEPA (2006)
 - University of Houston and Parsons (2006)
 - Weston (2006)
 - URS (2010)
 - Orion (2009)

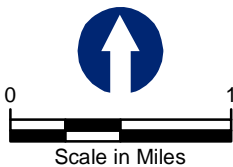
- Dioxin/Furans Subsurface Sample

Figure 4
Locations of Sediment Dioxin Data
SJRWP Sediment QAPP
SJRWP Superfund/MIMC and IPC

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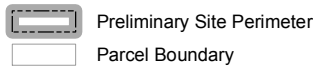
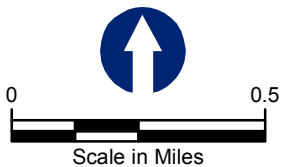
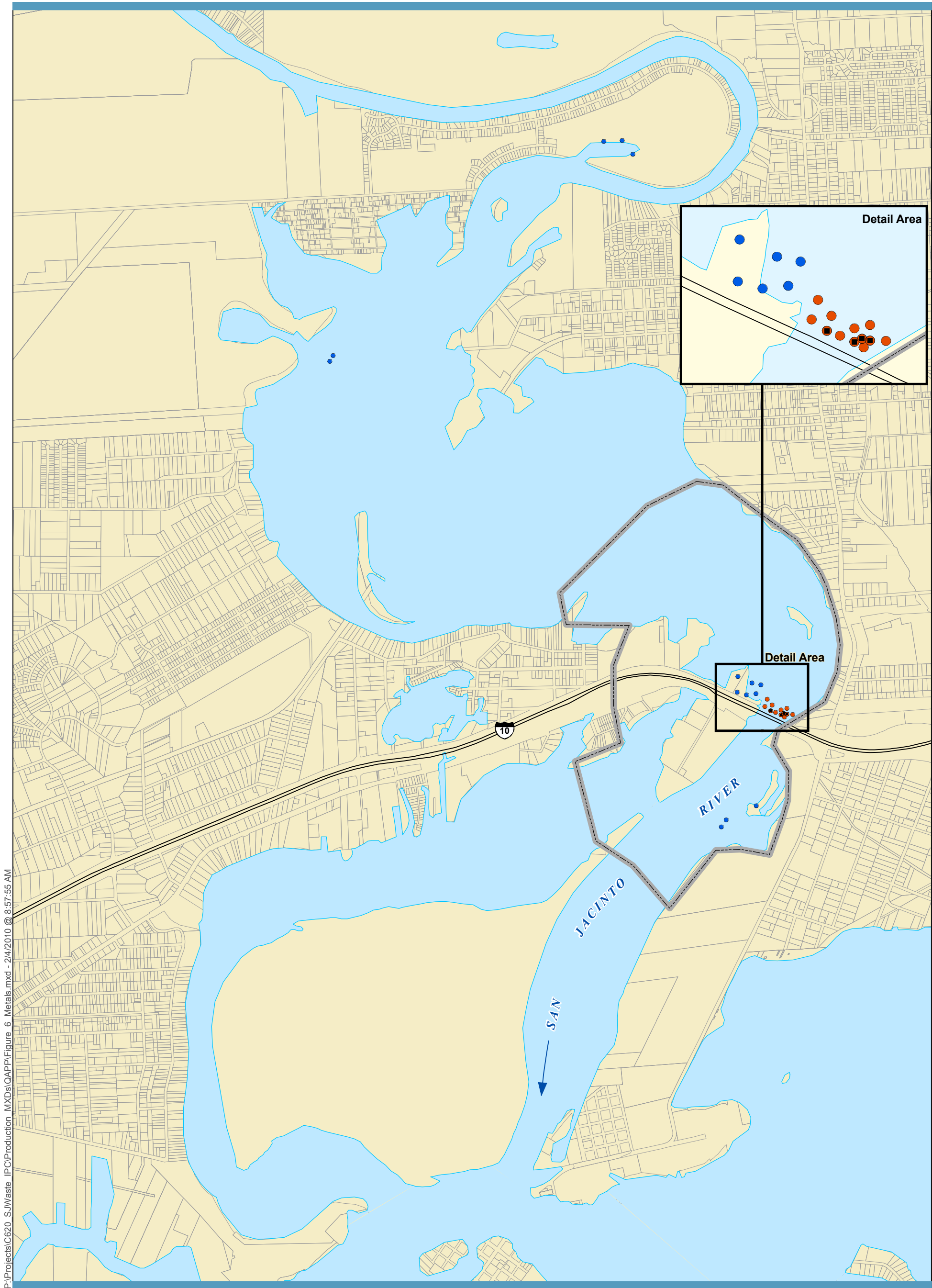


- Preliminary Site Perimeter
- Virgil C. McGinnes Trustee Parcel
- Study Area

FEATURE SOURCES:
Hydrology: Harris County Flood Control District
Transportation Lines: OpenStreetMap
Elevation Hillshade: USGS 3m DEM

Figure 5
Study Area Overview
SJRWP Sediment QAPP
SJRWP Superfund/MIMC and IPC

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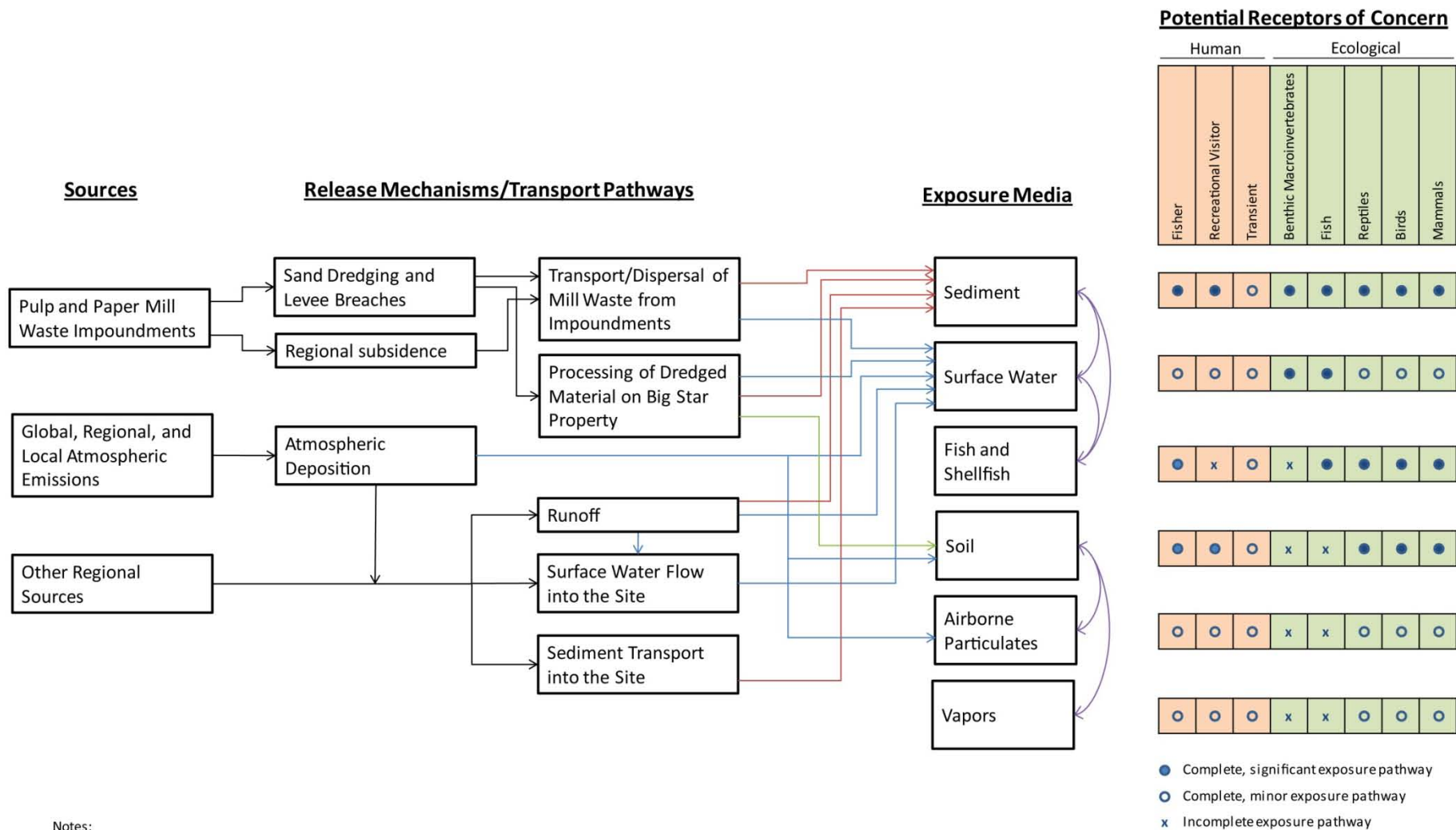


FEATURE SOURCES:
Parcel Boundaries: Harris County Appraisal District
Hydrology: Harris County Flood Control District

- Metal Surface Sample**
- TCEQ and USEPA (2006)
 - Weston (2006)
- Metal Subsurface Sample**
-

Figure 6
Locations of Sediment Metal Data
SJRWP Sediment QAPP
SJRWP Superfund/MIMC and IPC

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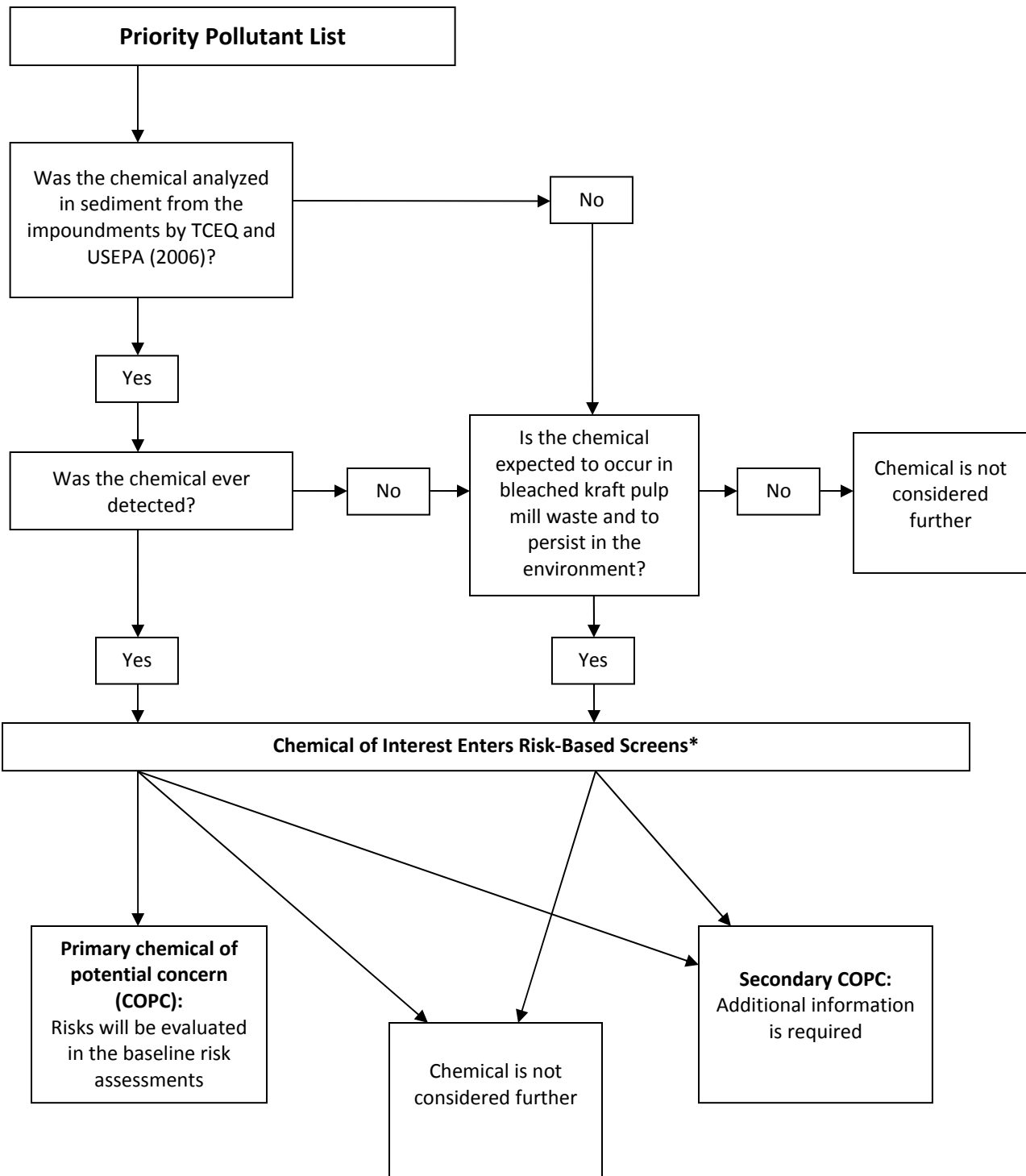


Notes:

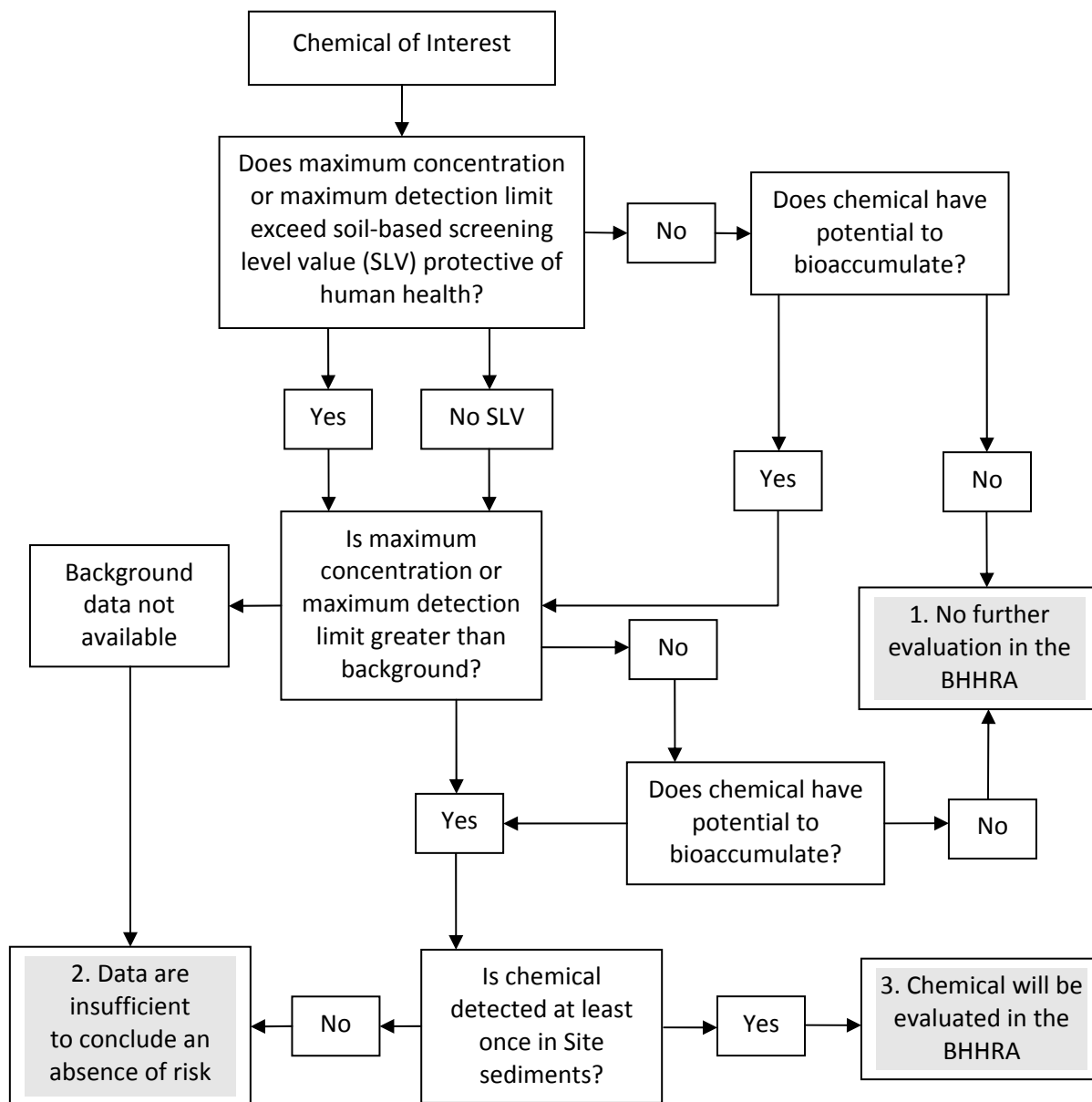
Other regional sources may include industrial effluents, publicly owned treatment works, and stormwater.

Curved lines indicate potential transport pathways for chemicals of potential concern among exposure media.

Benthic invertebrates include crabs and other crustaceans and shellfish consumed by all receptors, as well as polychaetes and other infauna consumed by fish, other marine life, birds and mammals.

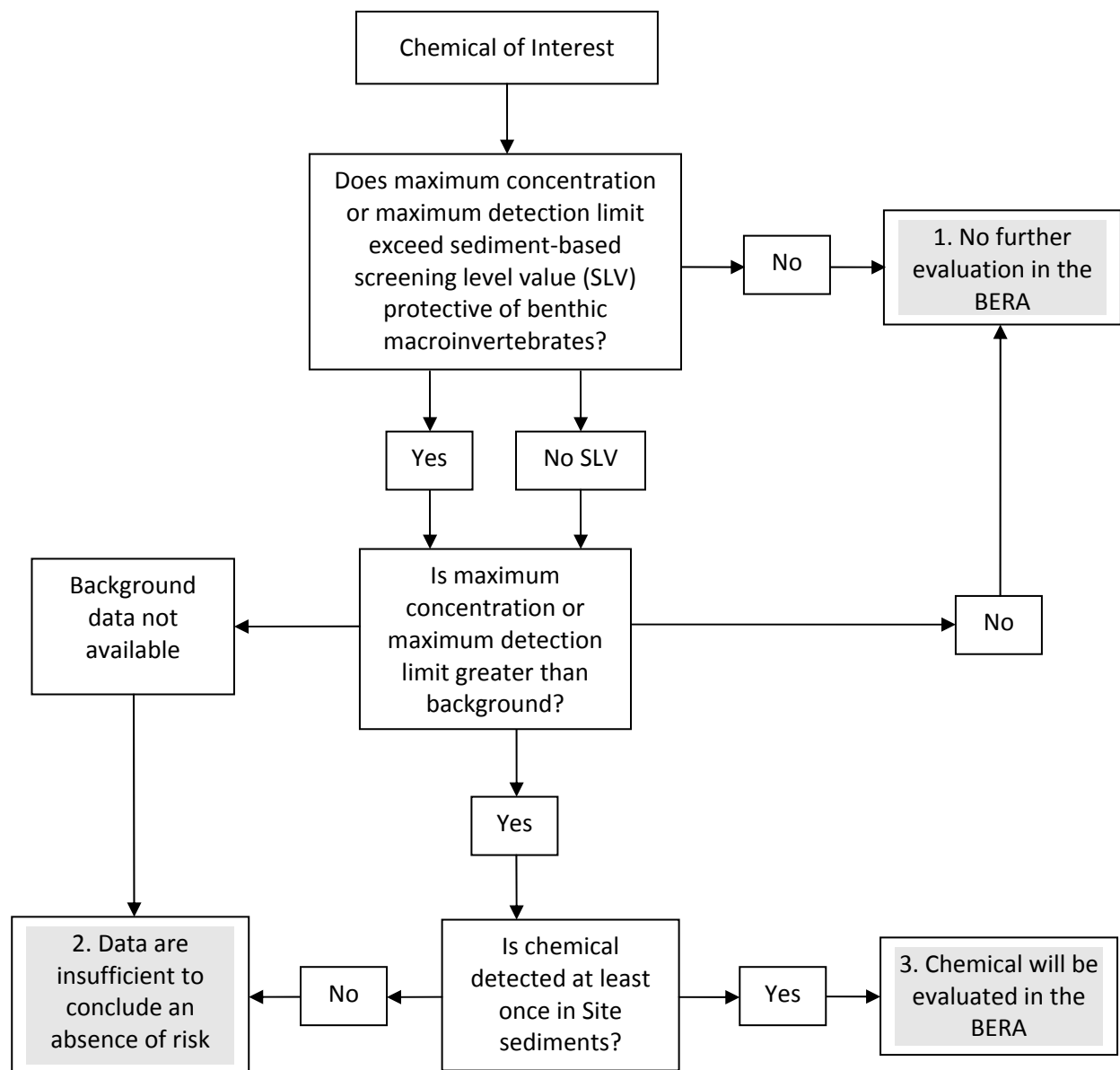


***Chemicals of Interest** are those that will enter the risk-based screening process. Three separate risk-based screens will be used: a) fish and wildlife, b) benthic invertebrates, and c) human health.



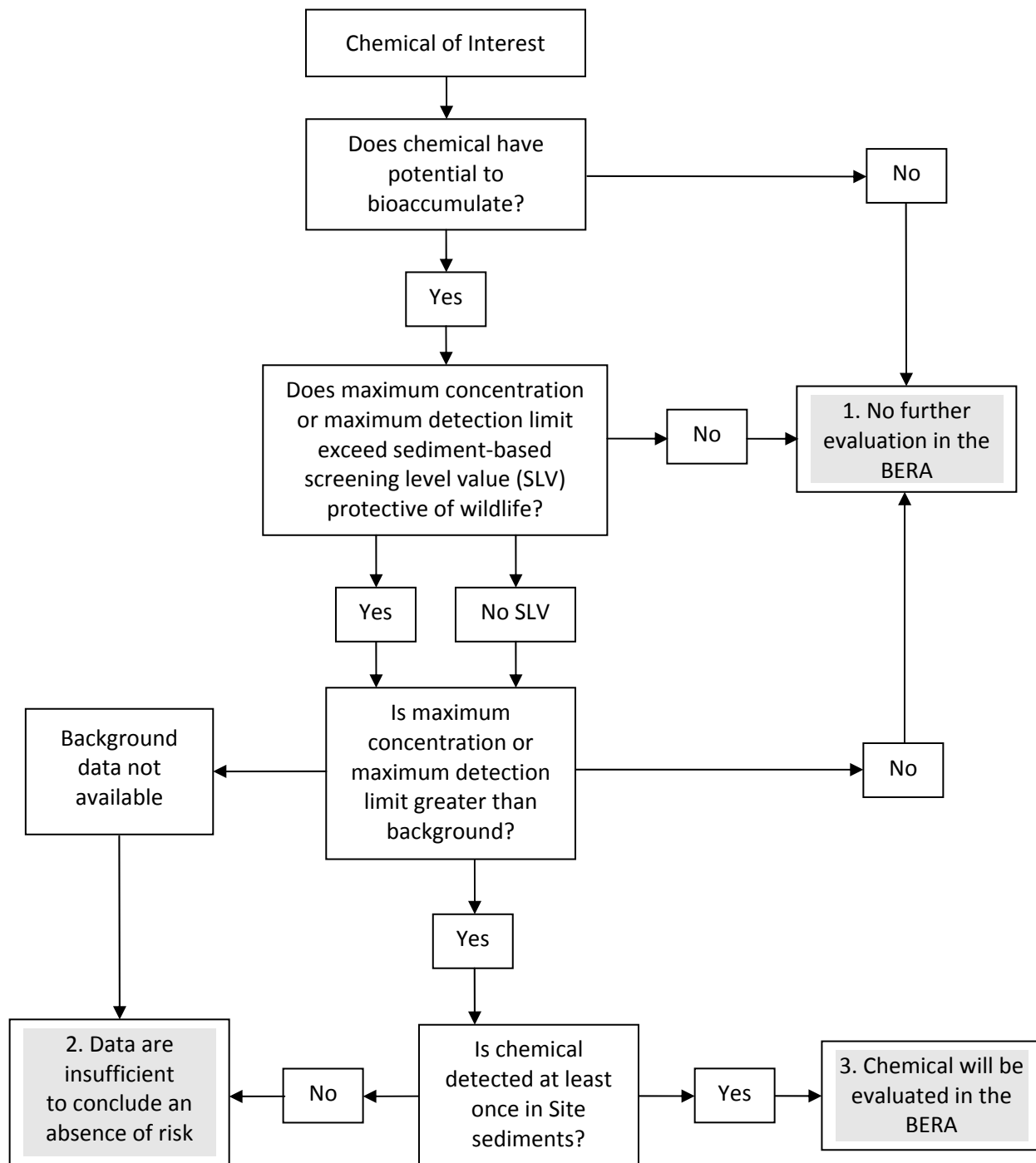
Outcomes:

1. Data are sufficient to conclude that there is an absence of risk to human health. **Chemical will not be evaluated further in the baseline human health risk assessment (BHHRA).**
2. Data are insufficient to conclude an absence of risk to human health. **Chemical is retained as a secondary chemical of potential concern (COPC).**
3. Data are sufficient to conclude that the chemical must be evaluated in the BHHRA. **Chemical is retained as a primary COPC.**



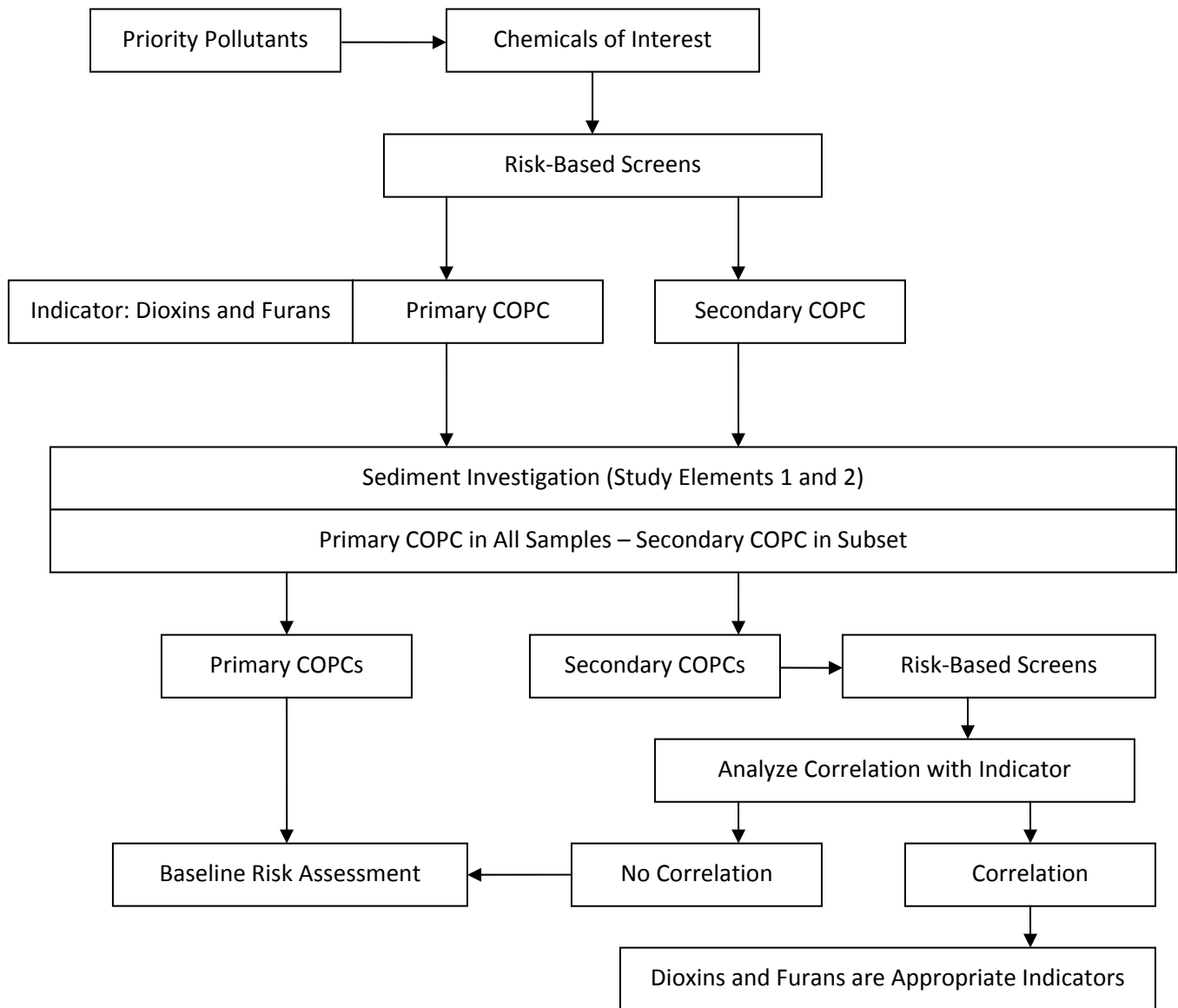
Outcomes:

1. Data are sufficient to conclude that there is an absence of risk to benthic macroinvertebrates. **Chemical will not be evaluated further in the baseline ecological risk assessment (BERA).**
2. Data are insufficient to conclude an absence of risk to benthic macroinvertebrates. **Chemical is retained as a secondary chemical of potential concern (COPC).**
3. Data are sufficient to conclude that the chemical must be evaluated in the BERA. **Chemical is retained as a primary COPC.**

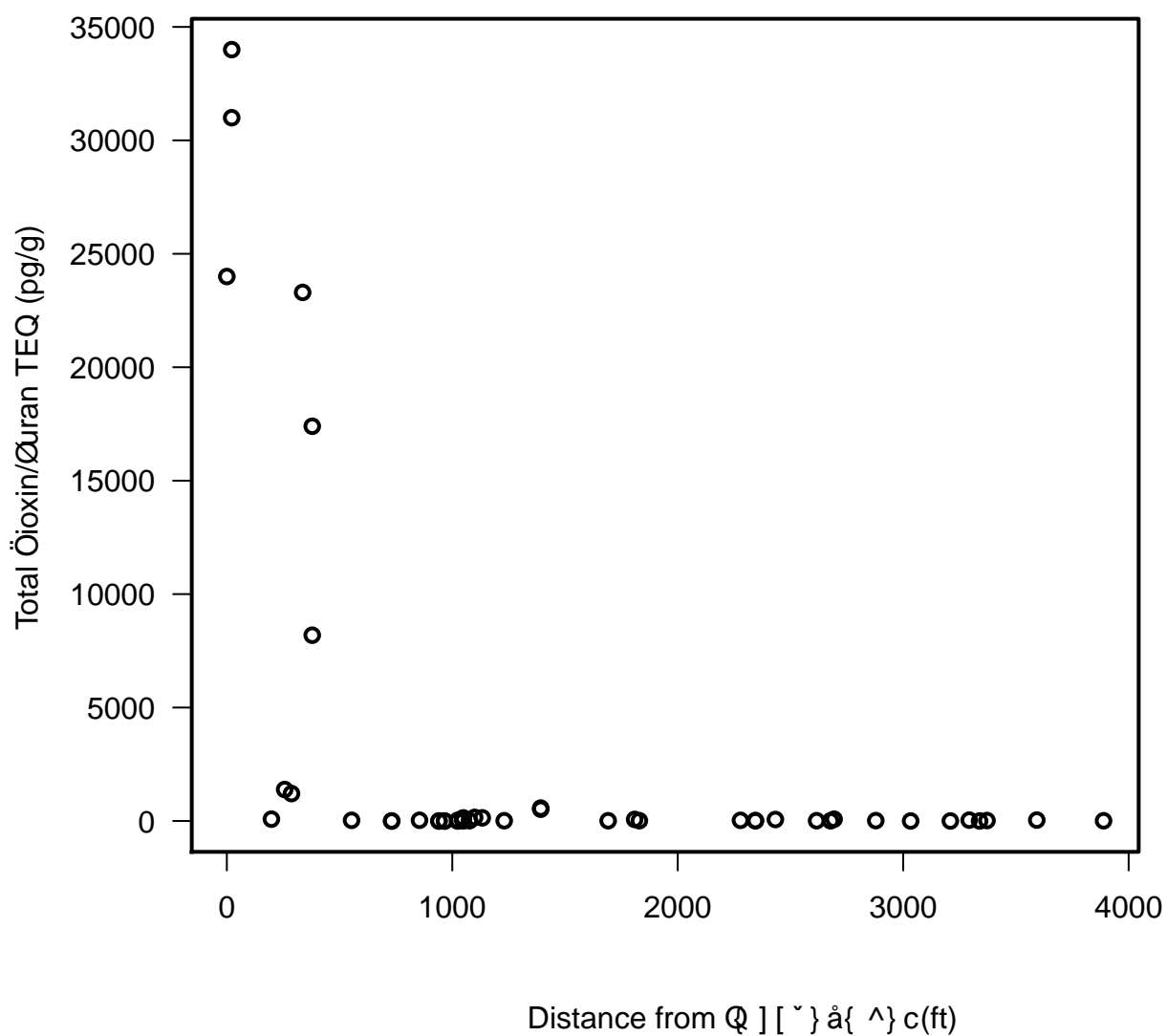


Outcomes:

1. Data are sufficient to conclude that there is an absence of risk to fish and wildlife. **Chemical will not be evaluated further in the baseline ecological risk assessment (BERA).**
2. Data are insufficient to conclude an absence of risk to fish and wildlife. **Chemical is retained as a secondary chemical of potential concern (COPC).**
3. Data are sufficient to conclude that the chemical must be evaluated in the BERA. **Chemical is retained as a primary COPC.**



COPC – chemical of potential concern



TEQ – toxicity equivalent

Figure 13

Change in Toxicity Equivalent Concentration with Distance
from the San Jacinto Impoundment
SJRW Sediment QAPP
SJRW Superfund/MIMC and IPC

Feb 03, 2010 11:38am ghowell K:\Jobs\090557-San Jacinto\090557-01 - San Jacinto\090557-01-RP-011.dwg FIG WM01

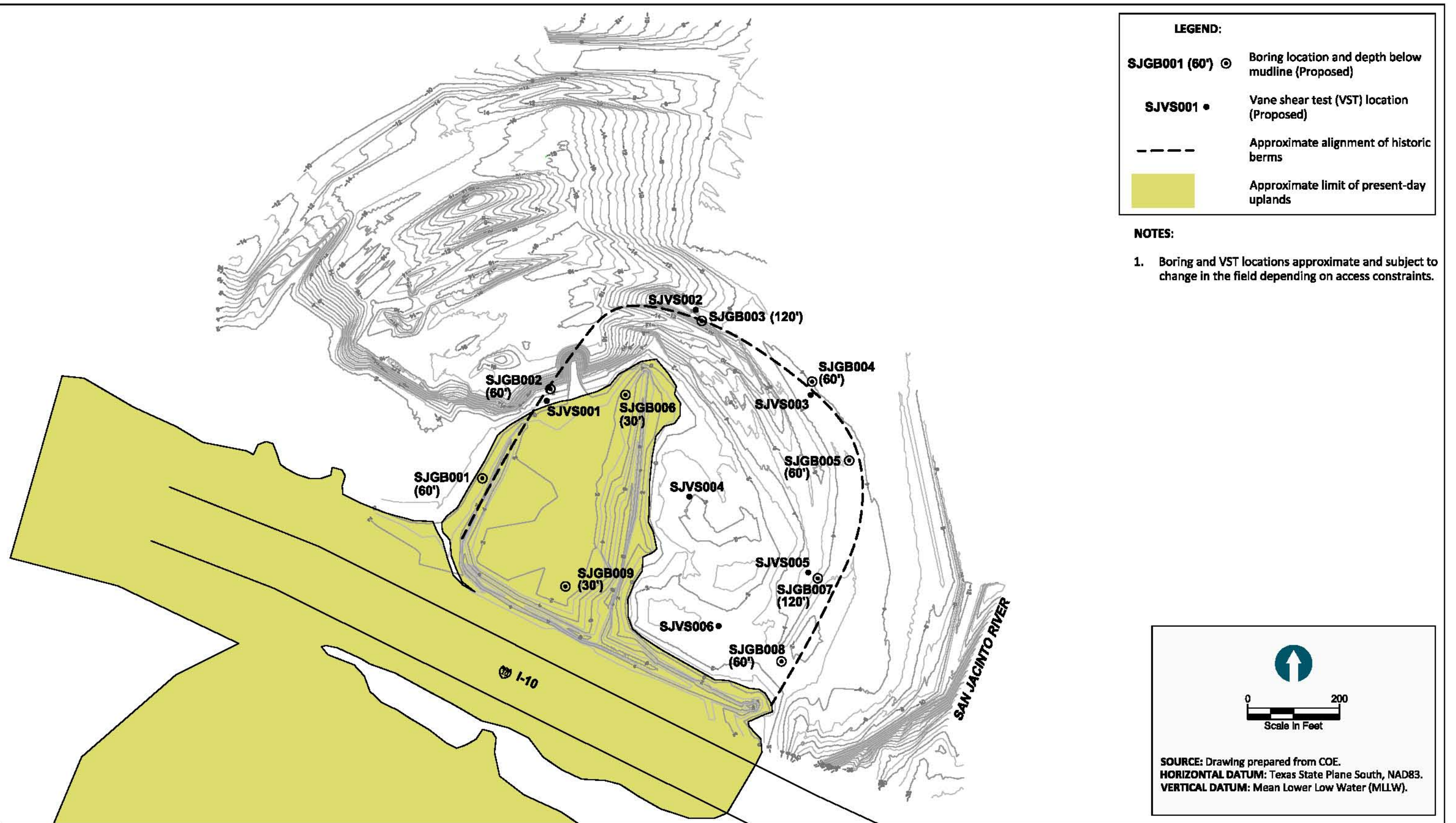
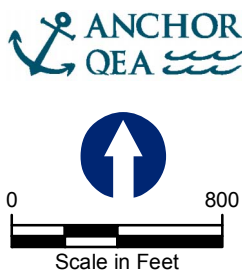


Figure 14
Proposed Geotechnical Borings and
Vane Shear Test Locations
San Jacinto Island



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- Preliminary Site Perimeter
- 1-Meter 1995 Bathymetric Contour
- Field Triplicate

FEATURE SOURCES:
Aerial Imagery: 0.5-meter 2008/2009 DOQQs -
Texas Strategic Mapping Program (StratMap), TNRS
Contours: NOS Survey H1016 (1995)

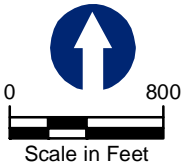
Proposed Locations

- Surface Sediment (Primary and Secondary COPCs)
- Surface Sediment (Primary COPCs)
- Surface Sediment (Primary and Secondary COPCs) and Core (Primary COPCs)
- Additional Geotechnical Samples From Core

Figure 15
Nature and Extent Sediment Sampling
Locations Within the Preliminary Site Perimeter
SJRW Sediment QAPP
SJRW Superfund/MIMC and IPC

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FEATURE SOURCES:
Aerial Imagery: 0.5-meter 2008/2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIRIS; Contours: NOS Survey H1016 (1995)

- Preliminary Site Perimeter
- 1-Meter 1995 Bathymetric Contour

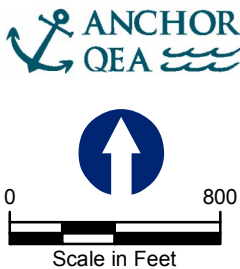
- Proposed Locations**
- Human Health Surface Sediment (Primary COPCs)
 - Human Health Surface Sediment and Subsurface Sediment (Primary COPCs)
 - Upstream Background (Primary and Secondary COPCs)
 - ERA (Primary COPCs)



Figure 16
Upstream Sediment Sampling Locations
SJRP Sediment QAPP
SJRP Superfund/MIMC and IPC

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 Preliminary Site Perimeter
 1-Meter 1995 Bathymetric Contour

Proposed Locations

-  Human Health Surface Sediment (Primary COPCs)
-  Human Health Surface Sediment and Subsurface Sediment (Primary COPCs)
-  ERA Surface Sediment (Primary COPCs)

FEATURE SOURCES:
Aerial Imagery: 0.5-meter 2008/2009 DOQQs - Texas Strategic Mapping Program (StratMap), TNIRIS; Contours: NOS Survey H1016 (1995)

Figure 17
Human Health and Ecological Exposure Sediment
Sampling Locations Within the Preliminary Site Perimeter
SJRP Sediment QAPP
SJRP Superfund/MIMC and IPC

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APPENDIX A
DRAFT SEDIMENT FIELD SAMPLING
PLAN
SAN JACINTO RIVER WASTE PITS
SUPERFUND SITE

DRAFT SEDIMENT FIELD SAMPLING PLAN

SAN JACINTO RIVER WASTE PITS SUPERFUND SITE

Prepared for

McGinnes Industrial Maintenance Corporation
International Paper Company
U.S. Environmental Protection Agency, Region 6

Prepared by



Integral Consulting Inc.
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February 2010

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List of Attachments

Attachment A1	Addendum 1 to the Overall Health and Safety Plan: Sediment Sampling Health and Safety Plan
Attachment A2	Standard Operating Procedures
Attachment A3	Field Forms
Attachment A4	USEPA Risk Assessment Guidance Forms (per the Unilateral Administrative Order Statement of Work)

LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
Anchor QEA	Anchor QEA, LLC
ASTM	American Society for Testing and Materials
ATV	all terrain vehicle
CDF	confined disposal facility
COC	chain-of-custody
COPC	chemical of potential concern
CU	consolidated undrained
DGPS	differential global positioning system
FL	Field Lead
FSP	Field Sampling Plan
GPS	global positioning system
HASP	Health and Safety Plan
I-10	Interstate Highway 10
Integral	Integral Consulting Inc.
NOAA	National Oceanic and Atmospheric Administration
QA	quality assurance
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance and quality control
QC	quality control
RI/FS	Remedial Investigation and Feasibility Study
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SOP	standard operating procedure
SOW	statement of work
SPT	Standard Penetration Test
UAO	Unilateral Administrative Order
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Service
VST	vane shear test

1 INTRODUCTION

This document presents the Field Sampling Plan (FSP) that has been prepared on behalf of the San Jacinto Group for the 2010 sediment study at the San Jacinto River Waste Pits (SJRWPs) Superfund Site (the Site). This FSP was prepared consistent with U.S. Environmental Protection Agency (USEPA) guidance (USEPA 1988, 1992) and requirements as required by the USEPA 2009 Unilateral Administrative Order (UAO; (USEPA 2009). Additional information on the Site history and a summary of existing data are provided in the Quality Assurance Project Plan (QAPP). Information on Site geology, physiographic, hydrological, cultural, and natural resources of the Site and information on fate and transport will be provided in the Remedial Investigation and Feasibility Study (RI/FS) Work Plan (in preparation).

The Site is located on the western bank of the San Jacinto River, immediately north of the Interstate Highway 10 (I-10) Bridge, in Harris County, Texas (Figure A-1). The property was acquired for the disposal of paper mill waste sludge from the Champion Paper Company in Pasadena, Texas. The on-site impoundments are believed to have been used in the mid-1960s for disposal of paper mill waste sludge, which were reportedly brought to the Site by barges (TCEQ and USEPA 2006). The sediment study is one of the tasks that will be conducted as part of the RI/FS for the Site.

The primary objective of the 2010 sediment study is to collect information on chemical concentrations and geotechnical properties of the sediment at the Site. Chemicals of potential concern (COPCs) data will also be collected from upstream background areas near the Site. As discussed in the QAPP, sediment data will be used to support Site characterization, risk assessments (i.e., human health and ecological), and remedial actions that will be conducted as part of the RI/FS.

To execute this study, Integral Consulting Inc. (Integral) and Anchor QEA, LLC (Anchor QEA) will conduct the field work and data analysis, with Integral responsible for execution of Study Elements 1 and 2, and Anchor QEA responsible for execution of Study Elements 3 and 4 (as discussed in the QAPP). The names and quality assurance (QA) responsibilities of

key project personnel for Anchor QEA and Integral who will be involved in sampling and analysis activities are provided in Figure 1 of the QAPP.

1.1 Overview

The sediment sampling design for the RI/FS incorporates a number of different components. The individual study components (as discussed in the QAPP) differ in the locations, depths, and analytes to be measured in the sediment. The sampling design can be summarized as follows:

- Surface sediment sampling and analysis of primary COPCs at 29 locations in and near the impoundments (Figure A-2) on a 500-foot (152-m) grid, and at four locations along the eastern perimeter of the original impoundments. Secondary COPCs will be measured at an additional 11 locations on the 500-foot (152-m) grid. Additional sediment from the 29 locations will be archived for later analysis of secondary COPCs, if necessary. These samples will provide data for the nature and extent, exposure, and fate and transport analyses. Data from locations from within the impoundment area (five stations) will allow characterization of waste materials.
- Surface sediment sampling and analysis of primary COPCs at an additional 19 locations within the Site boundary (Figure A-2), on a 1,000-foot (305-m) grid. These samples will provide data for the nature and extent, exposure, and fate and transport analyses. Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs.
- Collection of cores and analysis of primary COPCs at ten locations within approximately 1,000 feet (305 m) of the impoundment (Figure A-2). Additional sediment from these stations will also be archived for possible future analyses of secondary COPCs. These samples will provide data for the nature and extent evaluation and for dredgability assessments.
- Collection of surface samples and analysis of primary and secondary COPCs at 11 locations upstream of the Site, but downstream of the channelized portion of the San Jacinto River (Figure A-3), to allow estimation of local background conditions for the nature and extent, exposure assessments and fate and transport analysis.
- Collection of intertidal sediment samples at 30 locations in three different human exposure areas on three beaches (Figure A-4) within the Site to evaluate potential

human exposure and whether the beaches represent different exposure conditions for human receptors. Surface and subsurface sediment samples will be collected at all 30 stations at each of the three beaches. Half of the intertidal surface sediment samples will be analyzed for primary COPCs, with additional sediment archived for possible future analysis of secondary COPCs. Surface sediment samples from the other half of these stations will be archived for future analysis of primary and/or secondary COPCs, if necessary.

- In addition, half of the subsurface samples collected at Stations SJSH011 through SJSH020 will initially be analyzed for primary COPCs; the archived subsurface sediment samples from the other half of these stations and all of the subsurface samples from the other two beaches will be archived for possible future analysis of primary and/or secondary COPCs, if necessary.
- Collection of intertidal sediment samples for analysis of primary COPCs at ten locations upstream of the Site, but downstream of the channelized portion of the San Jacinto River (Figure A-3), for evaluation of human exposures under upstream background conditions. Surface and subsurface sediment samples will be collected at all 10 stations at this beach. Half of the surface intertidal sediment samples will be analyzed for primary COPCs. The other half of the surface and all of the subsurface samples will be archived for possible future analysis of primary and/or secondary COPCs, if necessary.
- Collection of intertidal samples from nine locations at three ecological exposure areas on the Site (Figure A-4) and three locations at one ecological exposure area upstream (Figure A-3) for characterization of exposure of ecological receptors such as wading birds. These samples will be analyzed for primary COPCs. Additional sediment from these stations will be archived for possible future analyses of secondary COPCs, if necessary.
- Sediment borings at nine locations and vane shear tests at six locations in the impoundment and in locations around the perimeter berms (Figure A-5). Measurements of sediment engineering characteristics (strength and settlement behavior) will be used to support engineering design for a confined disposal facility (CDF).

Some of the samples to be collected will be used for multiple elements of the overall study. Table A-1 summarizes the location to be sampled in terms of placement, depth, analytes, and study element. In general, surface sediment samples collected for the nature and extent evaluation will also be used to support the evaluations of exposure of aquatic receptors, sediment fate and transport, and sediment dredgability. Samples collected to support exposure assessments for humans and wildlife, and to support confined disposal facility (CDF) design, are more specialized in purpose and location.

To accomplish the objective of the 2010 sediment study, two field sampling teams will be deployed, one team each from Integral and Anchor QEA. The following tasks will be performed autonomously by the two teams (Table A-1):

- Integral team:
 - Collection of surface and subsurface sediment for chemical analyses within the San Jacinto River
 - Collection of surface and subsurface intertidal sediment (to the lowest low water level at time of sampling) along the intertidal of the San Jacinto River.
- Anchor QEA team:
 - Collection of sediment borings for measurements of geotechnical and engineering properties within the Site and also from the San Jacinto River
 - Collection of vane shear test (VST) information.

This FSP describes the field methods that will be used to collect sediment for the 2010 sediment study. The background, rationale, data quality objectives, and overall study design are described in detail in the QAPP. Section 2 of this FSP describes the field procedures and sample packaging and shipping requirements that will be followed by the technical team during the field study. Section 3 summarizes field documentation and chain-of-custody (COC) procedures. Field data reporting and field custody procedures are discussed in Section 4.

The following documents are provided as attachments to this FSP:

- Sediment Health and Safety Plan (HASP) Addendum 1. This document describes the

specific requirements and procedures that will be implemented to minimize the safety risk to personnel who carry out the field study program for sediment collection (Attachment A1). It is an addendum to the project's overall HASP (Anchor QEA 2009).

- Standard Operating Procedures (SOPs). The SOPs describe the procedures that will be used to collect surface and subsurface sediments (Attachment A2). Attachment A2 is separated into two components: Integral SOPs and Anchor QEA SOPs.
- Field Forms. This attachment contains examples of various forms that will be used during field sampling, including a corrective action record, a field change request form, and a COC form (Attachment A3).
- USEPA Risk Assessment Guidance Forms (per the UAO Statement of Work [SOW]). This attachment contains the risk assessment guidance forms from USEPA (1992) that were stipulated in Item 17a of the UAO SOW (Attachment A4).

2 SAMPLING PROCEDURES

The following sections describe the detailed procedures and methods that will be used during the 2010 sediment study, including sampling procedures, recordkeeping, sample handling, storage, and field quality control (QC) procedures. Sample collection and processing will be conducted in accordance with the SOPs provided in Attachment A2. Depending on field conditions, procedures specified in the referenced SOPs may be modified if necessary. All field activities will be conducted in accordance with the sediment HASP addendum that is provided in Attachment A1.

2.1 Schedule

The start date for the sediment study will be determined following USEPA approval of the QAPP. However, for planning purposes, it is anticipated that the first field sampling event will begin in late April/May 2010.

2.2 Field Survey and Sampling Methods

As mentioned above, it is anticipated that two field teams will implement this FSP. The Integral team will be responsible for collection of sediment samples for chemical analyses, and the Anchor QEA team will be responsible for collection of all borings and samples associated with the geotechnical and engineering properties analyses (Table A-1). The Anchor QEA team will also conduct the in situ VSTs for the study.

As discussed previously, surface and subsurface sediment chemistry samples will be collected from within the preliminary Site boundary (Figures A-2, A-4, and A-5) and from upstream background areas (Figure A-3). The following sections describe the sampling equipment, sampling methods, sample handling, and shipping.

2.2.1 Sampling Vessel, Field Equipment, and Supplies

Access to river sediments and to some of the intertidal stations (particularly at high tide) may require the use of either a boat or a barge. Some of the intertidal stations will be sampled at low tide, and accessed by land; a truck or van will be required in these cases. Any upland

stations that need to be accessed for geotechnical borings will require the use of a truck or all terrain vehicle (ATV) mounted drilling equipment.

2.2.1.1 Sampling Vessel

The sampling boat or barge will have enough space to accommodate a minimum of five people—three sampling team members, the vessel’s operator, and one USEPA oversight individual (if required)—and the following gear: sediment collection and compositing equipment, sample coolers, and multiple sampling equipment boxes containing sample jars and other ancillary equipment. The vessels used for sampling will have navigational lights, anchors, and basic sonar (e.g., fathometer). The vessel operator will be thoroughly familiar with the area of the river to be navigated.

Weather, river gauge height, and tides will be monitored using the following web sites:

- Weather conditions and forecasts: National Oceanic and Atmospheric Administration (NOAA) site for the Houston/Galveston area
(<http://www.weather.gov/forecasts/wfo/sectors/hgx.php#tabs>)
- Real-time stream elevation: U.S. Geological Service (USGS) 08072050 San Jacinto River near Sheldon, 10 miles upstream from the Site
(http://waterdata.usgs.gov/nwis/uv?site_no=08072050)
- Real-time data on wind direction, wind speed, and water elevation: USGS 08077637 Clear Lake Second Outflow Channel at Kemah, 22 miles south of the Site
(http://waterdata.usgs.gov/nwis/uv?site_no=08077637)
- Tides: NOAA site at Battleship Texas State Park, Station Id: 8770743, 3 miles southwest of the Site
(<http://tidesandcurrents.noaa.gov/noaatidepredictions/viewDailyPredictions.jsp?Stationid=8770743>).

2.2.1.2 Field Equipment and Supplies

Field equipment and supplies include sampling equipment, utensils, decontamination supplies, sample containers, coolers, shipping containers, log books and forms, personal protection equipment, and personal gear. Protective wear (e.g., gloves) is required to

minimize the possibility of cross-contamination between sampling locations. Additional information on protective wear required for this project is provided in Attachment A1.

Surface sediment samples (4 inches; 10 cm) for characterization of nature and extent and for exposure of ecological receptors, and surface sediment samples (6 inches; 15 cm) for characterization of human health exposure will be collected using stainless-steel spades, shovels, or hand-held corers; a modified petite-Ponar grab sampler, or a van Veen grab sampler (or equivalent type of equipment). A coring device (e.g., vibracorer from a boat, slide-hammer corer, gravity corer, thin-walled tubes, split-spoon sampler, or equivalent type of equipment) will be used for subsurface sediment collection.

Sample jars, preservatives, distilled/deionized water, coolers, and packaging material for the samples will be supplied by the analytical laboratory. Details on the numbers and type of sample containers are provided in the QAPP and in Table A-2 of this FSP. The Field Lead (FL) and field personnel in charge of sample handling in the field will use a sample matrix table (Table A-3) as a QC check to ensure that all samples have been collected at a given station. This table includes the total number and type of sample jars required for each analysis at each sampling station.

Commercially available, pre-cleaned jars will be used for the samples, and the testing laboratories will maintain a record of certification from the suppliers. The bottle shipment documentation will include batch numbers. With this documentation, jars can be traced to the supplier, and bottle-wash analysis results can be reviewed. The bottle-wash certificate documentation will be archived in Integral's project file.

Sample containers will be clearly labeled at the time of sampling. Labels will include the task name, sample location and number, sampler's initials, analyses to be performed, and sample date and time. Sample numbering and identification procedures are described in detail in Sections 3.6 and 3.7.

2.2.2 Sample Location Positioning

Latitude and longitude coordinates will be obtained at the locations where sediment samples are collected. A differential global positioning system (DGPS) will be used to document the sample collection locations. The standard projection method to be used during field activities is Horizontal Datum: NAD1983_StatePlane, Texas South Central, FIPS 4204, US feet. The positioning objective is to accurately determine and record the positions of all sampling locations to within ± 2 m. Proposed sediment sampling location coordinates are provided in Table A-4.

The DGPS unit consists of a global positioning system (GPS) receiver and a differential receiver located at a horizontal control point. At the control point, the GPS-derived position is compared with the known horizontal location, offsets or biases are calculated, and the correction factors are telemetered to the GPS receiver. Positioning accuracies on the order of ± 1 to 3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the appropriate quality of signal (SOP AP-06). The GPS unit provides the operator with a listing of the time intervals during the day when accuracies are decreased. Avoidance of these time intervals permits the operator to maintain better positioning accuracy (SOP AP-06).

2.2.3 Surface Sediment Sample Collection

The equipment and procedures that will be used to collect surface sediment samples during the 2010 sediment study are discussed in the following sections. The estimated numbers of field locations that will be sampled are listed in Table A-1. The holding time requirements for the sediment samples following field collection are specified in Table A-2.

Surficial sediment samples (0 to 4 inches; 0 to 10 cm) for characterization of nature and extent and for exposure of ecological receptors and surficial sediments (0 to 6 inches; 0 to 15 cm) for characterization of human health exposure may be collected with a variety of sampling equipment depending upon the conditions encountered in the field: stainless-steel spades or shovels, a stainless-steel hand corer, a modified petite-Ponar grab sampler, a power grab, or a van Veen grab sampler (or equivalent type of equipment), in accordance with standard

methods used by USEPA (1997). Methods for surface sediment sampling are provided in SOPs SD-04, SD-13, and SL-05, respectively.

One surface sediment sample will be collected at each location sampled for the nature and extent evaluation, except for the location in the impoundment area. In this location, three field replicates will be collected to ensure an accurate characterization of waste material present. The samples will be analyzed for primary COPCs and primary and secondary COPCs will be analyzed at Station SJNE022 (field triplicate station; see Section 2.3). Additional sediment from each station will be archived for possible future analysis, if necessary.

Three intertidal sampling areas will be sampled for human health: 1) the shoreline on both sides of the channel under the I-10 Bridge over the San Jacinto River; 2) the eastern shoreline of the sand separation area on the Big Star Property; and 3) the shoreline to the west of the shipping berth on the Big Star Property. Sediment will be sampled at ten stations from 0 to 6 inches (0 to 15 cm) at each of these areas. Sampling stations will be located between the high tide mark and the low tide mark. Five surface sediment samples from each of the exposure areas will be analyzed initially for primary COPCs. The remaining five surface samples from each area will be archived for possible future analysis, if necessary. Care will be taken to ensure that samples collected from Stations SJSH002, SJSH004, SJSH005, SJSH007, and SJSH010 (stations located on the shoreline near the I-10 Bridge) are sent for analysis rather than archived. A minimum of three grab samples will be collected within 1 foot (30 cm) from each other. Any vegetative material will be removed from the surface prior to sample collection and from the sample. Removal of material from the sample will be documented in the field log book.

At each of the intertidal sampling stations for ecological receptors, a minimum of three grab samples will be collected within 1 foot (30 cm) from each other. Sampling stations will be located between the high tide mark and the low tide mark. All of the surface sediment samples from each of the ecological exposure areas will be analyzed initially for primary COPCs. Additional sediment from each sampling location will be archived for possible future analysis of secondary COPCs, if necessary. Any vegetative material will be removed

from the surface prior to sample collection and from the sample. Removal of material from the sample will be documented in the field log book.

Material collected with the sampling device will be evaluated by the Integral FL for acceptability using the following criteria:

- The sampler is not overfilled
- Overlying water is present (may not be applicable to exposed intertidal sediment samples collected at low tide)
- The overlying water (if present) is not excessively turbid
- The sediment surface is relatively undisturbed
- An adequate penetration depth is attained (i.e., to enable sampling of the undisturbed surface sediment).

If a sample fails to meet any of the above criteria, it will be rejected and discarded away from the station.

After a sediment sample is judged to be acceptable, any overlying water will be siphoned off and the upper 4 inches (10 cm) (or 6 inches [15 cm] if the sample is intertidal sediment for human health exposure assessment) of sediment will be collected in accordance with (USEPA 1997) guidelines. If a grab sampler is used, then decontaminated stainless-steel spoons will be used to collect the sediment from the grab sampler. A stainless-steel ruler will be used with all sampling devices to ensure that the sampling criterion for adequate penetration depth has been met and that the correct amount (i.e., 4 inches [10 cm] or 6 inches [15 cm] for intertidal sediment samples for human health exposure) of sediment has been removed.

Surface sediments from the grab samples will be placed into a decontaminated, stainless-steel bowl and homogenized using a stainless-steel spoon or other stainless-steel mixing implement until the sediment attains a visually uniform color and texture. The sediment sample in the bowl will be covered with aluminum foil until a sufficient volume of sediment (approximately 2 L per station) is collected. Sediment subsamples will then be removed for the various kinds of laboratory analyses and for archiving.

The surface sediment composite samples will be placed in labeled, laboratory-cleaned sample containers with Teflon-lined lids (Table A-2). Each sample container will be clearly labeled with the task name, sample number, type of analysis to be performed, date and time, and initials of person(s) preparing the sample. Containers that will be frozen (i.e., archived samples) will have 0.5 to 1 inch (1.3 to 2.6 cm) of headspace above the sediment to prevent the jars from breaking during storage at the laboratory. Immediately after sample containers are filled, the samples will be stored on ice ($4\pm 2^{\circ}\text{C}$).

As stated above, the sample matrix table (Table A-3) shows the total number of sample jars for each analysis needed at each sampling station. Integral's FL and field personnel in charge of sample handling will use this table as a QC check to ensure that all samples at a given station are collected and that the appropriate sample container is used for each sample.

2.2.4 Subsurface Sediment Sample Collection

The equipment and procedures used to collect subsurface sediment samples during the 2010 sediment study are discussed in the following sections. The estimated numbers of field locations that will be sampled are listed in Table A-1. The holding time requirements for the sediment samples following field collection are specified in Table A-2.

The Integral team will collect a minimum of one core at each nature and extent station and a minimum of three cores at each intertidal station for human health exposure. If sample volume requirements dictate the need for additional sediment, then additional co-located core(s) will be collected and the sediment from the cores will be composited at 1-foot (30-cm) intervals. Any separate sediment horizons that are observed in the core will be noted on the field form (Attachment A3), but will not alter the collection interval of 1 foot (30 cm).

The Anchor QEA team will collect geotechnical-specific borings to address data gaps for geotechnical engineering analyses. The Anchor QEA team will also collect additional cores for geotechnical analyses at six of the nature and extent coring stations. These geotechnical core samples will not be composited but sent as a whole, undisturbed core segment to the testing laboratory. VSTs will also be conducted by the Anchor QEA team to supplement

surficial data that might be missed during the boring program in the area of the CDF. The Anchor QEA team will also collect grab samples that will be co-located with the VST locations to characterize the sediments and provide for VST correction factors.

2.2.4.1 Nature and Extent Cores

Sediment cores will be collected by the Integral team using a coring device (e.g., vibracorer with Lexan® liner and core catcher, an impact coring device, piston core, or equivalent type of equipment). Sampling methods for subsurface sediment sampling are provided in SOPs SD-08, SD-12, and SD-13, respectively.

A minimum diameter of 3 inches (7.6 cm) will be used for all cores. Cores will be collected in 1-foot (30-cm) intervals to refusal or to a maximum depth of 10 feet (3 m). Sediment will be collected from the entire sediment interval (i.e., 1 foot [30 cm]), and a discrete sample from the composited, homogenized sediment will be collected. Shorter core lengths will be accepted if native materials are encountered, based on visual inspection of the core, or if multiple attempts (i.e., two attempts) at coring a given sampling location do not provide the anticipated core length.

For cores that are collected from a sampling vessel, the core's position will be monitored by observing the angle of the winch line while the corer is being lowered in the water column. When the inlet of the corer is approximately 2 m above the sediment, the corer will stop being lowered, the boat location confirmed, and the angle of the hydrowire determined. When the angle of the hydrowire is less than 5 degrees, the corer will be lowered into the sediment at a rate of 30 cm/s or less. If the weather is windy or tidal conditions warrant it, the boat will be anchored before the core is lowered. Cable will be released through the winch until there is slack in the line. If the boat drifts significantly (e.g., because of wind or tidal conditions), slack in the line will be permitted only briefly to prevent pulling the corer out at an angle.

The corer will be retrieved at a controlled rate to minimize agitation of the core. Retrieval will be stopped as soon as the top of the corer reaches the water surface. If a core catcher is not installed at the bottom end of the core, a plug may be inserted in the bottom end of the

corer to prevent the core from slipping out when the corer is raised out of the water. The corer will be brought on board the sampling vessel and immediately stabilized to prevent it from tipping or falling. Care will be taken at all times to keep the corer in a vertical position. After the corer is secured onboard the sampling vessel, the polyethylene liner that contains the sample will be removed from the corer barrel and inspected.

Each core will be evaluated by Integral's FL for acceptability using the following criteria:

- The sediment surface is relatively undisturbed
- Any overlying water is not excessively turbid
- At least 80 percent core recovery relative to penetration is achieved.

If a sediment core fails to meet any of the above criteria, it will be rejected.

If less than 80 percent core recovery versus penetration is achieved, the recovered core will be retained but considered insufficient, and another attempt to recover a sediment core at the same location will be conducted. If the specified penetration depth is not achieved after two attempts, the station may be relocated slightly. If the slight relocation of the station does not improve the penetration depth, the station may be temporarily abandoned and Integral's project manager will be notified.

After the cores have been collected, both ends of the cores designated for chemical analysis will be securely capped; labeled with the station identifier, core section, and sediment orientation; and fastened in an upright position. The overlying water will be siphoned or drained off.

Processing of the core may occur either on the sampling vessel or at a specified location onshore. At the processing area, the core liner will be laid out horizontally on a clean work surface. The content of the core will be extruded with a plunger onto a clean sheet of aluminum foil. If the core contains a liner that cannot be extruded, the core liner will be cut lengthwise and the core split open. Split cores and hand cores collected without a liner will be placed next to a tape measure and a station identifier and photographed. Cores will be inspected for physical characteristics and described on a core profile form (see Attachment A3).

Cores designated for chemical analysis will be sectioned into 1-foot (30-cm) intervals. Sediment touching the sides of the core tube will be excluded from each sample. The sediment from each core section will be homogenized with a decontaminated stainless-steel mixing implement (e.g., spoon) until the sediment attains a visually uniform color and texture. The sediment sample in the bowl will be covered with aluminum foil until a sufficient volume of sediment (approximately 2 L per station) is collected. Sediment subsamples will then be removed for the various kinds of laboratory analyses and for archiving.

The subsurface sediment composite samples will be placed in labeled, laboratory-cleaned sample containers with Teflon-lined lids (Table A-2). Each sample container will be clearly labeled with the task name, sample number, type of analysis to be performed, date and time, and initials of person(s) preparing the sample. Containers that will be frozen (i.e., archived samples) will have 0.5 to 1 inch (1.3 to 2.6 cm) of headspace above the sediment to prevent the jars from breaking during storage at the laboratory. Immediately after sample containers are filled, the samples will be stored on ice ($4\pm 2^{\circ}\text{C}$).

As stated above, the sample matrix table (Table A-3) shows the total number of sample jars for each analysis needed at each sampling station. Integral's FL and field personnel in charge of sample handling in the field will use this table as a QC check to ensure that all samples at a given station are collected and that the appropriate sample container is used for each sample.

2.2.4.2 *Human Health Exposure Cores*

Sampling stations will be located between the high tide mark and the low tide mark. Sediment cores for human health exposure will be collected using a hand-held stainless steel corer. The subsurface sample of intertidal sediment for human health exposure will be collected from a depth of 6 to 12 inches (15 to 30 cm) and collocated with the surface sediment samples discussed above in Section 2.2.3. A minimum of three cores will be collected at each location, and sediment will be collected from the entire sediment interval. Care will be taken at all times to keep the corer in a vertical position.

Five subsurface sediment samples from the same locations where surface sediment samples were collected from the eastern shoreline of the Big Star Property (see above) will be analyzed initially for primary COPCs. All of the remaining subsurface samples will be archived for possible future analysis, if necessary.

Each core will be evaluated by Integral's FL to ensure that the sediment surface is relatively undisturbed. If the specified penetration depth (1 foot; 30 cm) is not achieved after two attempts, the station will be relocated slightly. If the slight relocation of the station does not improve the penetration depth, the station may be temporarily abandoned and Integral's project manager will be notified.

Processing of the core will occur in the field. The core will be laid out horizontally on a clean work surface. The content of the core will be extruded with a plunger onto a clean sheet of aluminum foil. Extruded hand cores will be placed next to a tape measure and a station identifier and photographed. Cores will be inspected for physical characteristics and described on a core profile form (see Attachment A3).

The sediment from the 6 to 12-inch (15 to 30-cm) core section will be homogenized with a stainless-steel mixing implement (e.g., spoon) until the sediment attains a visually uniform color and texture. Sediment touching the sides of the core tube will be excluded from each sample. The sediment sample in the bowl will be covered with aluminum foil until a sufficient volume of sediment (approximately 2 L per station) is collected. Sediment subsamples will then be removed for the various kinds of laboratory analyses and archiving.

The subsurface sediment composite samples will be placed in labeled, laboratory-cleaned sample containers with Teflon-lined lids (Table A-2). Each sample container will be clearly labeled with the task name, sample number, type of analysis to be performed, date and time, and initials of person(s) preparing the sample. Containers that will be frozen (i.e., archived samples) will have 0.5 to 1 inch (1.3 to 2.6 cm) of headspace above the sediment to prevent the jars from breaking during storage at the laboratory. Immediately after sample containers are filled, the samples will be stored on ice ($4\pm 2^{\circ}\text{C}$).

As stated above, the sample matrix table (Table A-3) shows the total number of sample jars for each analysis needed at each sampling station. Integral's FL and field personnel in charge of sample handling in the field will use this table as a QC check to ensure that all samples at a given station are collected and that the appropriate sample container is used for each sample.

2.2.4.3 *Geotechnical Borings*

Subsurface sediment will be collected by advancing borings at selected locations to obtain geotechnical data using the Standard Penetration Test (SPT) with a split-spoon sampler and thin-walled tube sampling. Locations of the borings are shown in Figure A-5.

The proposed sampling intervals and test parameters for borings are identified in Table A-5. Final sampling locations and depth intervals may vary depending on updated survey data, access, and the determinations of the field geologist. Borings will be drilled to varying depths based on the proposed location of the berm so that the exploration program provides a representative characterization of subsurface conditions across the Site.

The boring program consists of two 120-foot-deep (below mudline) borings and five 60-foot (18-m)-deep borings around the perimeter of the CDF. Within the CDF footprint, two 30-foot (9-m)-deep borings will be advanced. Samples will be collected continuously from 0 to 10-foot and at 5-foot (1.5-m) depth intervals below 10 feet in each boring. The actual depth interval for thin-walled tube sampling will be selected in the field by the geologist depending on the subsurface conditions encountered during drilling, so that the thin-walled tube will target fine-grained materials and/or depth intervals that are proposed for either Triaxial or consolidation testing.

Undisturbed thin-walled tube samples will be collected following American Society for Testing and Materials (ASTM) D1587 *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes* and will be handled following ASTM D3213 *Standard Practice for Handling, Storing, and Preparing Soft Undisturbed Marine Soil*. These standards cover the methods for project/cruise reporting, collecting, handling, transporting, and storing soft cohesive undisturbed marine sediment. Geotechnical testing will include grain size (ASTM D422), Atterberg limits (ASTM D4318), moisture content (ASTM D2216), specific

gravity (ASTM D854), permeability (ASTM D5084), Consolidated Undrained (CU) Triaxial Compression (ASTM D4767), and consolidation testing (ASTM D2435). Table A-6 summarizes the uses of the geotechnical laboratory testing that will be performed and provides the applicable ASTM standard that will be applied to each test (ASTM 2003).

The subsequent sections provide details regarding split-spoon and thin-walled tube sample collection methods, processing methods, and the boring design plan.

2.2.4.3.1 Split-Spoon and Thin-walled Tube Sample Collection Methods

Sediment samples will be collected by advancing a series of borings around the Site. Depending on drill rig availability, either hollow-stem auger or mud rotary methods will be used. The over-water boring locations will be advanced from a barge.

The hollow-stem auger or mud rotary casing will be advanced into the sediment to the top of the depth interval of interest. After the target depth is reached, sediment will be collected by advancing a split-spoon or thin-walled tube. For split-spoon sampling, a 2-inch (5 cm) outside diameter split spoon will be driven 18 inches. Field conditions may require a 3-inch (7.6 cm) outside diameter split spoon. Undisturbed samples will be obtained by pushing a 3-inch (7.6 cm) diameter thin-walled tube 2 feet using a constant push from hydraulics reacting off the drill rig (per ASTM D1587).

A lead line measurement of depth to the mudline will be taken prior to sampling or drilling over the water. The measurement will be cross checked by recording the lengths of hollow-stem auger or casing used to reach the mudline surface below the water. Where soft sediment is present at the sampling location, this method of cross check will be closely reviewed by the field geologist to evaluate whether the auger/casing has penetrated below the mudline under its own weight.

During split-spoon sampling, the number of hammer blows required to advance the spoon in 6-inch (15-cm) increments will be recorded as a measure of sediment density using the SPT (see Section 3.2 for detailed information on boring logs). This test is an approximate measure of sediment density and consistency. As described in ASTM D 1586, this test employs a

standard 2-inch (5-cm) outside diameter split-spoon sampler. Using a 140-pound (64-kg) hammer free falling 30 inches (76 cm), the sampler is driven into the sediment for 18 inches (46 cm). The number of blows required to drive the sampler the last 12 inch (30 cm) is the standard penetration resistance. This resistance, or blow count, measures the relative density of granular sediments and the consistency of cohesive solids.

If dense materials (i.e., more than 50 blows per 6-inch [15-cm] drive) preclude driving the total 18-inch (46-cm) sample, the penetration resistance is entered in one of two ways. For sample sizes less than 6 inches (15 cm), enter the total number of blows over the number of inches of penetration on the boring log (e.g., “50/3”). For samples larger than 6 inches, sum the total number of blows completed after the first 6 inches of penetration. This sum is expressed over the number of inches driven that exceed the first 6 inches (e.g., “50/9”). In determining the final SPT blow count, the number of blows needed to drive the first 6 inches are not reported, as this first interval is considered potentially disturbed by the drilling action.

The tube ends of the undisturbed thin-walled tube samples will be sealed in the field, per SOP 6.3 (see Attachment A2) to prevent leakage of porewater. The tubes will be maintained in a vertical orientation and transported to the laboratory with minimal disturbance. The undisturbed thin-walled tubes will be sealed and submitted to the analytical lab for further testing. The sample intervals for lab testing will be determined by the Anchor QEA FL based on review of the field logs. Fine-grained sediment subsamples will be analyzed by consolidation testing, CU triaxial shear, grain size distribution, water content, permeability, specific gravity, and Atterberg limits. The lab will also record the Unified Soil Classification System (USCS) classification of the undisturbed samples.

Depending on the analyses, the geotechnical boring will either be placed in new, labeled clean plastic or glass jars, labeled zip-lock bags (double bagged), or will be maintained as an intact core (e.g., thin-walled tube). Each sample container will be clearly labeled with the task name, sample number, depth interval, type of analysis to be performed, date and time, and initials of person(s) preparing the sample. Geotechnical samples will be stored at room temperature out of direct sunlight.

As stated above, a sample matrix table (which will be prepared prior to initiating the sampling event) will show the kinds of geotechnical samples needed at each station. Anchor QEA's FL and field personnel in charge of sample handling in the field will use this table as a QC check to ensure that all samples and field tests at a given station are collected and that the appropriate container is used for each sample.

2.2.4.3.2 Split-Spoon Sample and Thin-Walled Tube Processing Methods

Split-spoon samples will be logged on Site by an experienced field geologist or geotechnical engineer (see Section 3.3 for detailed information on split-spoon logs). Discrete samples will be taken directly from the selected depth interval and spooned into laboratory-supplied jars for geotechnical physical testing. The samples will be placed in a cooler out of direct sunlight until transported to the testing lab. A COC form will be logged by the processing staff and relinquished to the courier and then to lab staff.

Thin-walled tube samples do not allow for direct observation or logging in the field. When recovered from the boring, the tubes will be measured for amount of recovery and checked to ensure the tube was not dented or damaged while driving or removing. The tubes will then be quickly cleaned, sealed with a plastic cap and duct tape on both ends, and labeled with boring name, sample name, date, approximate depth, and the location of the top of the sample with respect to the orientation at which it was removed from the subsurface. Every effort will be made to store and transport the thin-walled tubes with minimal disturbance in the upright, vertical position.

2.2.4.4 Vane Shear Tests

Six VSTs are planned for the CDF area. Figure A-5 depicts proposed vane shear sampling locations; the sampling scheme is summarized in Table A-7. At each location, tests will be performed at the 1-foot (30-cm), 2-foot (60-cm), and 3-foot (90-cm) depth intervals below mudline. Peak and residual strength measurements will be made for each location and depth interval.

In situ strength of the near surface sediments will be measured using field vane shear equipment. This information will be used to supplement surficial data that will potentially

be missed in the first sample interval during the boring program. Test results will be corrected using geotechnical index parameters measured on surface grab samples collected at each VST location. The subsequent sections provide details regarding vane shear collection methods and the sampling design plan.

At each VST location, a lead line measurement of depth to the mudline will be taken prior to testing. Where water is too deep to complete the test (e.g., approximately more than 12 to 15 feet [3.7 to 4.6 m] of water), the field geologist may elect to field-adjust the VST location. After the water depth has been measured, the time of testing will be marked on the field log. This time, combined with the date, will be used to estimate river stage elevation during the test using the nearest tide gage. The mudline elevation of each VST will be computed by subtracting the depth to mudline from the water level elevation.

2.2.4.4.1 Vane Shear Collection Methods

Vane shear data will be collected from a shallow draft boat or the drill barge using VST equipment. VSTs will be performed in accordance with ASTM D2573 and the manufacturers' recommended SOP. The VST equipment will be operated by pushing the vane into the sediment to the required depth and making sure that the scale-ring is set to the zero position. The handle is turned clockwise slowly until the lower part of the scale follows the upper part around, indicating failure. Peak undrained shear strengths are obtained in the sediment at the vane and will be recorded on field forms (Attachment A3; see Section 3.4 for detailed information on VST logs).

Once peak strength has been measured, the VST will be rotated 360 degrees relatively quickly several times. The scale will be re-zeroed, and another strength measurement will be completed. After recording the data for each test, the handle will be held firmly and allowed to return to the zero position.

Surface grabs will be co-located with vane shear locations in order to characterize the material and to standardize the field VST results using laboratory tests. Surface sediment will be collected using a van Veen grab sampler, Ekman grab sampler, or box grab sampler.

As stated above, a sample matrix table (which will be prepared prior to initiating the sampling event) will show the kinds of VST samples needed at each station. Anchor QEA's FL and field personnel in charge of sample handling in the field will use this table as a QC check to ensure that all samples and field tests at a given station are collected and that the appropriate sample container is used for each sample.

2.2.5 *Equipment Decontamination*

Before sampling begins at a location, the grab sampler will be scrubbed with a standard detergent (e.g., Alconox® or Liquinox®), rinsed with water (river, tap, or deionized water), air-dried, and rinsed with river water. Equipment used for compositing the sediment samples (i.e., stainless-steel bowls and spoons) will follow the same basic decontamination sequence, except that the final rinse will be with laboratory-grade distilled/deionized water. After cleaning, the decontaminated sample homogenizing equipment will be covered with aluminum foil to protect it from possible contamination.

Prior to subsurface sampling, all core liners will be washed in sequence with a standard detergent (e.g., Alconox® or Liquinox®), rinsed with laboratory grade distilled/deionized water, and then air-dried. During storage and transport, decontaminated Lexan® core liners will be capped at both ends to prevent contamination.

All non-dedicated sampling equipment that comes into contact with the sediment samples (e.g., core catchers, grab samplers, core liners, stainless-steel bowls, and utensils) will be decontaminated prior to use and between samples. Non-dedicated sampling equipment will be decontaminated following procedures in SOP SD-01 (Attachment A2), except that no solvent rinse will typically be used. If samples are collected that include obvious oily contamination, the sampling equipment used to collect and process them will be decontaminated using a separate decontamination station dedicated to heavily impacted equipment. This equipment will be wiped with a solvent following the initial decontamination, and it will undergo a second decontamination sequence using the standard decontamination procedures used for the non-oil-impacted equipment.

2.3 Field Quality Control Samples

Field QC samples will be used to assess sample variability and evaluate potential sources of contamination. The types of QC samples that will be collected for the 2010 sediment study are described in this section. Detailed information on quality assurance and quality control (QA/QC) procedures, limits, and reporting are described in detail in the QAPP. The estimated numbers of field QC samples to be collected is listed in the sample matrix table (Table A-3). If QC problems are encountered, they will be brought to the attention of the Integral's QA coordinator. Corrective actions, if appropriate, will be implemented to meet the task's data quality indicators.

Field QC samples will include field split samples, field triplicate samples, standard reference materials, equipment filter wipe blanks, and filter blanks. The following QC samples will be collected in the field and analyzed by the analytical laboratory:

- Field split samples will be collected and analyzed to assess the variability associated with sample processing and laboratory variability. Blind field split samples will be collected at a minimum frequency of 1 field split sample per 20 sediment sampling stations. Samples will be assigned unique numbers and will not be identified as field splits to the laboratory. Field split samples will be collected from both surface and subsurface sediment samples for chemical analysis. A minimum of one field split sample will be collected for each kind of sample collected. A field split sample will be collected at every twentieth station.
- Field triplicate samples are co-located samples collected in an identical manner over a minimum period of time to provide a measure of the field and laboratory variance, including variance resulting from sample heterogeneity. Field triplicate samples will be prepared by collecting three completely separate samples from the same station and submitting them for analysis as separate samples. During the 2010 sediment study, field triplicate samples will be collected at one station (SJNE022) and will be placed approximately 10 m (33 feet) apart, roughly in the shape of a triangle.
- Standard reference materials are samples of known concentration that have typically undergone multilaboratory analyses using a standard method. Reference materials provide a measure of analytical performance and/or analytical method bias. Where available, reference materials for sediments will be submitted from the field at a

frequency of once per sampling event.

- Equipment filter wipe blanks will be collected to help identify possible contamination from the sampling environment or from the sampling equipment (e.g., stainless-steel spade, coring device, spoons, and bowls). Equipment filter wipe blanks will be generated at approximately 5 percent of the sediment sampling stations at a minimum. Field equipment filter wipe blanks will be collected from both surface and subsurface sediment samples for chemical analysis. All equipment wipe samples will be clearly noted in the field log (e.g., sample identifier, equipment type, date and time of collection, analysis, and filter lot number).
- A minimum of one field equipment filter wipe blank will be collected for each kind of sampling equipment used for chemical analyses. A filter wipe blank will be collected at every twentieth station. One equipment wipe will be prepared for each analysis type. If multiple analyses are requested, separate sets of filter wipes will be collected for each analysis type for each kind of sampling equipment used, as the equipment can be wiped down only once for each piece of filter paper. This ensures that the filter wipe result represents the most conservative estimate of cross contamination for each analysis type. (Note: Filter papers must be stored in their original box, wrapped carefully in three layers of aluminum foil, or contained in a glass jar. The filter paper box cannot be stored in plastic bags or containers.)
- Filter blanks are prepared in the field to evaluate potential background concentrations present in filter paper used for the equipment filter wipe blank. Filter blanks will be collected at a minimum frequency of one for each lot number of filter papers used for collecting the equipment wipe blanks.

2.4 Sample Packaging and Transport

As mentioned above, sample coolers and packing materials will be supplied by the analytical laboratories. Individual sample jars will be labeled and placed into plastic bags and sealed. Samples will then be packed in a cooler lined with a large plastic bag. Glass jars will be packed to prevent breakage and separated in the cooler by bubble wrap or other shock-absorbent material. Ice in sealed plastic bags will then be placed in the cooler to maintain a temperature of approximately 4°C ($\pm 2^\circ\text{C}$). When the cooler is full, the COC form will be placed into a zip-locked bag and taped to the inside lid of the cooler. A temperature blank

will be added to each cooler. Each cooler will be sealed with two COC seals, one each on the front and side of the cooler. Labels indicating “This End Up ” with an arrow and “Fragile” will be attached to each cooler.

The shipping containers will be clearly labeled (i.e., name of task, time and date container was sealed, person sealing the cooler, and company name and address) for positive identification. These packaging and shipping procedures are in accordance with U.S. Department of Transportation regulations (49 CFR 173.6 and 49 CFR 173.24). Coolers containing samples for chemical analyses will be transported to the laboratory by courier or overnight shipping service.

After the chemistry samples have been received by the laboratory, they will be stored under refrigeration ($4\pm 2^{\circ}\text{C}$). Archive sediment samples collected from each composite sample for possible future analysis will be stored frozen at -20°C .

2.5 Study-Derived Wastes

Any excess phosphate-free, detergent-bearing liquid wastes from decontamination or any sample remaining after processing will be deposited in the vicinity of the collection area. Any dry waste (e.g., contaminated boots, bibs, Tyvek™ suits, contaminated sediments) present at the end of the sampling event will be segregated and containerized (e.g., 50-gallon drums) and disposed of by a subcontractor specialized in hazardous waste removal. The subcontractor will be required to have, at a minimum, a drum management service that provides the following:

- Proper waste identification including full analytical capability
- Pick up and disposal of a broad range of hazardous wastes
- Safe and proper transportation
- Environmentally sound treatment and disposal
- Regularly scheduled service visits with manifest and label preparation.

All disposable materials used for sample collection and processing, such as paper towels and gloves, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies that do not contain Site sediment will be removed from the Site by

sampling personnel and placed in a normal refuse container for disposal at a solid waste landfill.

3 FIELD DOCUMENTATION

The integrity of each sample from the time of collection to the point of data reporting must be maintained. Proper record-keeping and COC procedures will allow samples to be traced from collection to final disposition. Representative photographs will be taken of each area where samples are collected (e.g., near the impoundment, downstream of the I-10 Bridge, upstream of the preliminary Site perimeter, and at each intertidal and upland station). A photograph will be taken of each subsurface sediment interval collected for nature and extent and for geotechnical testing. Site photos from various angles and close-up views of the overall conditions will also be collected.

3.1 Field Log Book

All field activities and observations will be noted in a log book. The field log book will be a bound document and may contain individual field and sample log forms (depending on the sampling activity). Information will include personnel, date, time, station designation, sampler, types of samples collected, and general observations. Any changes that occur during sampling (e.g., personnel, responsibilities, or deviations from the FSP) and the reasons for these changes will be documented. The log book will identify on-site visitors (if any) and the number of photographs taken at each sampling location. Each FL is responsible for ensuring that their respective field log book and all field data forms are correct.

Requirements for log book entries will include the following:

- Log books will be bound, with consecutively numbered pages.
- Removal of any pages, even if illegible, will be prohibited.
- Entries will be made legibly with black (or dark) waterproof ink.
- Unbiased, accurate language will be used.
- Entries will be made while activities are in progress or as soon afterward as possible (the date and time that the notation is made should be recorded, as well as the time of the observation itself).
- Each consecutive day's first entry will be made on a new, blank page.
- The date and time, based on a 24-hour clock (e.g., 0900 a.m. for 9:00 a.m. and 2100 for 9:00 p.m.), will appear on each page.

In addition to the preceding requirements, the person recording the information must initial and date each page of the field log book. If more than one individual makes entries on the same page, each recorder must initial and date each entry. The bottom of the page must be signed and dated by the individual who makes the last entry.

Log book corrections will be made by drawing a single line through the original entry, allowing the original entry to be read. The corrected entry will be written alongside the original. Corrections will be initialed and dated and may require a footnote for explanation.

The type of information that may be included in the field log book and/or field data forms includes the following:

- Task name, task location, and task number
- Task start date and end date
- Weather conditions
- Name of person making entries and other field staff
- On-site visitors, if any
- Sampling vessel, if any
- Station name and location
- Date and collection time of each sample
- The sample number for each sample to be submitted for laboratory analysis
- The sampling location name, date, gear, and sampling location coordinates derived from GPS
- Specific information on each type of sampling activity
- The sample number, date and time of collection, equipment type, and the lot number for the box of filter papers used for field QC samples
- Observations made during sample collection, including weather conditions, complications, and other details associated with the sampling effort
- Sample description (source and appearance, such as sediment type, color, presence of anthropogenic material, and presence and type of biological structures, other debris, oil sheens, and odor)
- Sediment penetration depth (nearest 0.5 cm) based on sediment depth at the center of the excavation
- Any visible debris near any of the sampling locations

- Any surface vegetation that is removed from the sampling location prior to sampling
- The locations of any surface water runoff or seeps that are located near any of the sampling stations
- The number of photographs taken at the sampling location
- A record of Site health and safety meetings, updates, and related monitoring
- Any deviation from the FSP and reasons for deviation.

In addition, a sampling location map will be updated during sampling and will be maintained throughout the sampling event. All log books must be completed at the time that any observations are made. Copies of all log books and forms will be retained by the technical team.

3.2 Boring Logs

The blow counts that occur during thin-walled tube collection will be plotted on boring logs at their respective sample depths. The field geologist will record field conditions and drive notes on a standard boring log (Attachment A3). Logs will include the following information:

- Date and time of collection of each sediment core sample
- Names of field personnel collecting and handling the samples
- Type of sampling equipment used (e.g., split-spoon diameter, hammer weight, free fall height, and hammer deployment method)
- Observations made during sample collection, including weather conditions, complications, and other details associated with the sampling effort
- The sample station identification
- Length and depth intervals of each core section and estimated recovery
- Qualitative notation of apparent resistance during driving
- Any deviation from the approved FSP.

3.3 Split-Spoon Logs

Prior to subsampling from either the split-spoon or the thin-walled tube, a sediment description of each sample will be recorded on a standard boring log (Attachment A3) by an

experienced field geologist or geotechnical engineer. The following parameters will be noted in the logs:

- Sample recovery
- Physical sediment description in accordance with the USCS (includes sediment type, moisture, density/consistency of sediment, and color)
- Odor (e.g., hydrogen sulfide, or petroleum)
- Visual stratification, structure, and texture
- Vegetation
- Debris (e.g., woodchips or fibers, concrete, or metal debris)
- Evidence of biological activity (e.g., detritus, shells, tubes, bioturbation, or live or dead organisms)
- Presence of oil sheen.

3.4 Vane Shear Test Logs

The following parameters will be noted in the vane shear test logs:

- Peak undrained shear strengths
- Peak undrained strength (recorded as the residual undrained shear strength)
- Values on the graduated scale
- Position of the hole
- Depth.

3.5 Chain-of-Custody Procedures

Samples are in custody if they are in the custodian's view, stored in a secure place with restricted access, or placed in a container secured with custody seals (see SOP AP-03). A COC record will be signed by each person who has custody of the samples and will accompany the samples at all times. Copies of the COC will be included in laboratory and QA/QC reports. Attachment A3 contains an example of the COC form that will be used during the 2010 sediment study.

At a minimum, the form will include the following information:

- Site name

- FL's name and team members responsible for collection of the listed samples
- Collection date and time for each sample
- Sample type (i.e., sample for immediate analysis or archive)
- Number of sample containers shipped
- Requested analyses
- Sample preservation information (if any)
- Name of the carrier relinquishing the samples to the transporter, noting date and time of transfer and the designated sample custodian at the receiving facility.

Integral's FL or Anchor QEA's FL (or delegate) will be the designated field sample custodian for their respective sampling events and will be responsible for all sample tracking and COC procedures for the samples that their respective teams collected in the field. The field sample custodian will be responsible for final sample inventory and will maintain sample custody documentation. The field sample custodian will complete COC forms prior to removing samples from the field. Upon transferring samples to the laboratory sample custodian (if a local laboratory is selected) or shipping courier (as appropriate), the field sample custodian will sign, date, and note the time of transfer on the COC form. The original COC form will be transported with the samples to the laboratories. All samples will be shipped to the testing laboratories in either coolers or shipping containers sealed with custody seals.

Each laboratory will designate a sample custodian who will be responsible for receiving samples and documenting their progress through the laboratory analytical process. The sample custodian for each laboratory will establish the integrity of the custody seals upon sample arrival at the laboratory. The laboratory sample custodian will also ensure that the COC and sample tracking forms are properly completed, signed, and initialed upon receipt of the samples.

When the laboratory receives the samples, the laboratory sample custodian will conduct an inventory by comparing sample labels to those on the COC document. The custodian will enter the sample number into a laboratory tracking system by task code and sample designation. The custodian will assign a unique laboratory number to each sample and will be responsible for distributing the samples to the appropriate analyst or for storing samples at the correct temperature in an appropriate secure area.

3.6 Station Numbering

All stations will be assigned a unique identification code based on a designation scheme designed to suit the needs of the field personnel, data management, and data users. Station numbers will include “SJ” to indicate San Jacinto followed by a two-letter code for the type of sample to be collected at a given location (NE = nature and extent, SH = shoreline, GB = geotechnical boring, and VS = vane shear). The letters will be followed by a three-digit number (e.g., 001, 002, or 003). The station numbers will increase as the stations move upstream. An example station number for the 2010 sediment study would be SJNE033.

Station numbers will not be recorded on sample labels or COC forms to prevent analytical laboratories from seeing the relationships between samples and stations.

3.7 Sample Identifiers

Each sediment sample from a given station will also have a unique label identifier. Sample identifiers will be established before field sampling begins and assigned to each sample as it is collected. Sample identifiers consist of codes designed to fulfill three purposes: 1) to identify related samples (i.e., field split samples) to ensure proper data analysis and interpretation; 2) to obscure the relationships between samples so that laboratory analysis will be unbiased by presumptive similarities between samples; and 3) to track individual sample containers to ensure that the laboratory receives all of the material associated with a single sample. To accomplish these purposes, each container is assigned a sample number and a tag number. These codes and their uses are described below:

- A sample identifier for each surface sample will be created as follows: the station number (e.g., SJNE033), followed by a two-letter code for the kind of sample collected at a given location (GR = grab sample, CR = core, GB = geotechnical boring, and VS = vane shear). In addition, subsurface core samples for chemical analyses will also have a final alpha character attached to the sample identifier that will distinguish between the different sample intervals of the core (e.g., A = 0 to 1 foot [0 to 30 cm], B = 1 to 2 feet [30 to 60 cm], C = 2 to 3 feet [60 to 90 cm], and so on, to refusal or to a maximum depth of 10 feet [3 m]). Example identifiers for a surface sediment sample and a co-located coring station would be SJNE033-GR1 and SJNE033-CR1A, SJNE033-CR1B, SJNE033-CR1C, and so on. If a second core was required at a given

station to obtain the required sample volume, then example sample identifiers for this second core would be SJNE033-CR2A, SJNE033-CR2B, SJNE033-CR2C, and so on.

- The sample number is an arbitrary number assigned to each sediment sample collected (e.g., SD0001, SD0002) for chemical analysis. All subsamples of a composited field sample will have the same sample number. Each field split sample and each field triplicate will have a different sample number, and the sample numbers of related field QC samples may not share any content. The sample number appears on the sample containers and the COC forms.
- Sample numbering for geotechnical borings will consist of the boring location number, followed by a dash, followed by a sequential sample number in the form of S and a digit. Thus, at location SJGB001, the samples would be numbered SJGB001-S1, SJGB001-S2, and so on.
- The test number at a vane shear location will consist of the test location followed by a dash, followed by the test depth (in feet below mudline), and ending in P or R (P = peak shear strength, R = residual shear strength). Thus for location SJVS001, the tests would be reported as SJVS001-1P, SJVST001-1R, SJVS001-2P, and so on.
- A unique numeric sample tag number will be attached to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, each container will have the same sample number and a different sample label with a unique sample tag number. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted). The sample tag number will appear on the COC forms. Tag numbers are used by laboratories only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Sample numbers will be assigned sequentially in the field, and sample labels will be preprinted with tag numbers.

For equipment filter wipe blanks, sequential numbers starting at 900 will be assigned instead of station numbers. For example, the first filter wipe blank for a surface sediment sample collected with a stainless steel spoon and stainless steel bowl will be labeled as SDFW-901S, whereas the second filter wipe blank for a subsurface sediment sample collected with a

coring device will be labeled as SDFW-902C (SD = sediment, FW = filter wipe, S = stainless steel spoon and bowl, and C = core).

4 FIELD DATA MANAGEMENT AND REPORTING PROCEDURES

During field operations, effective data management is critical to providing consistent, accurate, and defensible data and data products. Daily field records (a combination of field log books, field forms, if any, and COC forms) will make up the main documentation for field activities. Upon completion of sampling, field notes, data sheets (if any), and COC forms will be scanned to create an electronic record. Field data will be manually entered into the project database. One hundred percent of the transferred data will be verified based on hard copy records. Electronic QA checks to identify anomalous values will also be conducted following entry.

5 REFERENCES

- Anchor QEA. 2009. Health and Safety Plan San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Anchor QEA, Ocean Springs, MS.
- ASTM. 2003. *Annual Book of ASTM Standards*. Volume 04.08. American Society for Testing and Materials, Philadelphia, PA.
- NOS. 1995. Survey H1016. National Geophysical Data Center integrated National Ocean Service hydrographic survey data into GEODAS' (Geophysical Data System) data management system. <http://www.ngdc.noaa.gov/mgg/dat/geodas/docs/hyd93.htm>.
- TCEQ and USEPA. 2006. Screening Site Assessment Report San Jacinto River Waste Pits, Channelview, Harris County, Texas. TXN000606611. Texas Commission on Environmental Quality and U.S. Environmental Protection Agency.
- USEPA. 1988. Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 1992. Guidance for Data Useability in Risk Assessment. Parts A and B. Final. Publication 9285.7-09. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
- USEPA. 1997. Recommended Quality Assurance and Quality Control Guidelines for the Collection of Environmental Data in Puget Sound. In: Recommended protocols for measuring selected environmental variables in Puget Sound. U.S. Environmental Protection Agency, Puget Sound Estuary Program, Seattle WA.
- USEPA. 2009. Unilateral Administrative Order for Remedial Investigation/Feasibility Study. U.S. EPA Region 6 CERCLA Docket No. 06-03-10. In the matter of: San Jacinto River Waste Pits Superfund Site Pasadena, Texas. International Paper Company, Inc. & McGinnes Industrial Management Corporation, respondents.

TABLES

Table A-1
Number of Locations Sampled^a

Sample Group	Sampling Method and Depth	Number of Locations	Sample Locations	Analytes	Study Elements	Sampling Team
Site surface sediment, primary COPCs	Grab sampler, surface 10 cm (0-4 in.)	52 ^b	152-m (500-ft) grid within 305 to 457 m (1,000 to 1,500 ft) of the waste pit and Big Star property, 305-m (1,000-ft) grid elsewhere	Primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived.	Nature and extent, ecological exposure, fate and transport	Integral
Impoundment characterization sample	Grab sampler, surface 10 cm (0-4 in.)	5	Within the impoundment area	1 station for primary and secondary COPCs, organic carbon, grain size, and solids; 4 stations for primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived at these 4 stations.	Nature and extent, characterization of waste materials	Integral
Site surface sediment, all COPCs	Grab sampler, surface 10 cm (0-4 in.)	11	Selected locations on a 152-m (500-ft) grid within approximately 305 m (1,000 ft) of the waste pit (coincident with core locations)	Primary and secondary COPCs, organic carbon, grain size, solids, and specific gravity	Nature and extent, ecological exposure, fate and transport	Integral
Site subsurface sediment	Cores to refusal, sectioned at 30-cm (1-ft) intervals	10	Selected locations on a 152-m (500-ft) grid within approximately 305 m (1,000 ft) of the waste pit	Primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived. (Atterberg limits and specific gravity at all core locations)	Nature and extent, dredging assessment	Integral - Chemistry cores; Anchor QEA - Geotechnical cores
Shoreline sediment for human health risk assessment	Surface 0-15 cm (0-6 in.) and subsurface 15-30 cm (6-12 in.)	30	Ten per beach on three beaches	5 surface sediment samples from each of the exposure areas and the corresponding subsurface sediment samples from the eastern shoreline of the Big Star property will be analyzed initially for primary COPCs. The remaining 5 surface samples from each area, 5 subsurface samples from the eastern shoreline of the Big Star property, and all 10 subsurface samples from the other two exposure areas will be archived.	Exposure for human health risk assessment	Integral
Shoreline sediment for ecological risk assessment	Grab sampler, surface 10 cm (0-4 in.)	9	Three in each of three locations where ecological exposures are anticipated	Primary COPCs, organic carbon, grain size, and solids. Sediment for analysis of secondary COPCs will be archived.	Exposure for ecological risk assessment	Integral
Upstream background surface samples	Grab sampler, surface 10 cm (0-4 in.)	11	Upstream in San Jacinto River on four transverse transects	Primary and secondary COPCs, organic carbon, grain size, solids, and specific gravity	Nature and extent, ecological exposure, fate and transport	Integral
Upstream shoreline sediment for human health risk assessment	Surface 1-15 cm (0-6 in.) and subsurface 15-30 cm (6-12 in.)	10	Ten per beach on one beach	Primary COPCs, organic carbon, grain size, and solids on 5 surface samples. Remainder of surface samples and all of the subsurface samples will be archived.	Exposure for human health risk assessment	Integral
Upstream shoreline sediment for ecological risk assessment	Grab sampler, surface 10 cm (0-4 in.)	3	Three on one beach where ecological exposures are anticipated	Primary COPCs, organic carbon, grain size, solids, and specific gravity. Sediment for analysis of secondary COPCs will be archived.	Exposure for ecological risk assessment	Integral
Soil borings in the impoundment and berm	Various depths depending on location	9	In areas of berm reconstruction and in the impoundment area.	Atterberg limits, specific gravity, soil strength, soil permeability, and soil compressibility	CDF design	Anchor QEA
Vane shear tests in the impoundment and berm	Surface	6	In areas of berm reconstruction and in the impoundment area	Vane shear and triaxial tests	CDF design	Anchor QEA

Notes

CDF = confined disposal facility

COPC = chemical of potential concern

a - Numbers do not include field quality control samples, and cores, which generate more than one "sample," are counted only once.

b - Numbers include all Site surface samples for primary COPCs for nature and extent evaluations (48 locations) and surface sediment samples to characterize the impoundment (4 locations)

Table A-2
Sample Containers, Preservation, and Holding Time Requirements

Matrix	Container ^a		Laboratory	Parameter	Preservation	Holding Time	Sample Size ^b
	Type	Size					
Sediment							
	WMG	8 oz.	TBD	Percent moisture (EPA 160.3)	4±2°C	6 months	10 g
				TOC	4±2°C	28 days	1 g
				Metals	4±2°C	6 months	10 g
				Mercury	4±2°C	28 days	5 g
	WMG	16 oz.	TBD	Grain Size	4±2°C	6 months	100 g
	WMG	8 oz.	TBD	Atterberg limits	4±2°C	N/A	225 g
				Percent moisture (ASTM D 2216)	4±2°C	6 months	10 g
				Specific gravity	4±2°C	N/A	
	WMG	8 oz.	TBD	Dioxins/furans	4±2°C/Deep frozen (-20°C) ^c / -10°C ^d	1 year/1 year ^e	50 g
	WMG	8 oz.	TBD	SVOCs	4±2°C	14 days/40 days ^e	50 g
	WMG	2 oz.	TBD	VOCs	4±2°C; do not freeze	14 days	5 g
	WMG	8 oz.	NA	Archival	4±2°C/ Deep frozen (-20°C) ^c	N/A	N/A
	Thin wall sampler	--	TBD	Sediment permeability	Airtight seal	6 months ^f	N/A
	Thin wall sampler	--	TBD	Consolidated undrained triaxial compressive strength	Airtight seal	6 months ^f	N/A
	Thin wall sampler	--	TBD	Sediment compressibility	Airtight seal	6 months ^f	N/A
Equipment Filter Wipe Blanks							
	HDPE	4 oz.	TBD	Metals	4±2°C	6 months	1 Wipe
	HDPE	4 oz.	TBD	Mercury	4±2°C	28 Days	1 Wipe
	AG	4 oz.	TBD	Dioxins/furans	4±2°C	1 year/1 year ^e	1 Wipe
	AG	4 oz.	TBD	SVOCs	4±2°C	7 days/40 days ^e	1 Wipe

Notes

AG = amber glass

HDPE = high density polyethylene

Table A-2
Sample Containers, Preservation, and Holding Time Requirements

NA = not applicable

SVOC = semivolatile organic compound

TOC = total organic carbon

VOC = volatile organic compound

WMG = wide mouth glass

a - The size and number of containers may be modified by the analytical laboratory.

b - Sample sizes may be modified once laboratory selection is made.

c - Samples will be shipped to the laboratory on ice at $4\pm 2^{\circ}\text{C}$. Once received at the laboratory, samples will be stored at -20°C .

d - Extracts will be stored at -10°C .

e - Holding time for samples prior to extraction/ holding time for extracts.

f - Published holding time does not exist. Holding time shown is based on best professional judgment

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)				
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC	
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs												Archival
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a												8oz WMG ^a
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze												4±2°C/ Deep frozen (-20°C) ^b
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C					
<input type="checkbox"/> SJGB001	SJGB001-S__	Geotech 60ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB002	SJGB002-S__	Geotech 60ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB003	SJGB003-S__	Geotech 120ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB004	SJGB004-GR1	Surface grab	Additional characterization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> SJGB004	SJGB004-S__	Geotech 60ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB005	SJGB005-GR1	Surface grab	Additional characterization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> SJGB005	SJGB005-S__	Geotech 60ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB006	SJGB006-S__	Geotech 30ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB007	SJGB007-GR1	Surface grab	Additional characterization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> SJGB007	SJGB007-S__	Geotech 120ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJGB008	SJGB008-GR1	Surface grab	Additional characterization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> SJGB009	SJGB008-S__	Geotech 30ft boring ^d	Source station							<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>						
<input type="checkbox"/> SJVS001	SJVS001-1P/R	Vane shear	Source station												<input type="checkbox"/>					
<input type="checkbox"/> SJVS002	SJVS002-1P/R	Vane shear	Source station												<input type="checkbox"/>					
<input type="checkbox"/> SJVS003	SJVS003-1P/R	Vane shear	Source station												<input type="checkbox"/>					
<input type="checkbox"/> SJVS004	SJVS004-1P/R	Vane shear	Source station												<input type="checkbox"/>					
<input type="checkbox"/> SJVS005	SJVS005-1P/R	Vane shear	Source station												<input type="checkbox"/>					
<input type="checkbox"/> SJVS006	SJVS006-1P/R	Vane shear	Source station												<input type="checkbox"/>					
<input type="checkbox"/> SJNE001	SJNE001-GR1	Surface grab	Within Site Boundary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> FW Blank	SDFW-901S	Equipment filter wipe blank	Within Site Boundary												<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
<input type="checkbox"/> SJNE002	SJNE002-GR1	Surface grab	Within Site Boundary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> SJNE003	SJNE003-GR1	Surface grab	Within Site Boundary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											
<input type="checkbox"/> SJNE004	SJNE004-GR1	Surface grab	Within Site Boundary	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>											

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)									
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC						
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival																
																				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a
																				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b /-10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b /-10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C										
<div><input type="checkbox"/></div> <div>SJNE005</div>	SJNE005-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE006</div>	SJNE006-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE007</div>	SJNE007-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE008</div>	SJNE008-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE009</div>	SJNE009-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE010</div>	SJNE010-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE011</div>	SJNE011-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE012</div>	SJNE012-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE012</div>	SJNE012-CR1	Core	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>											
<div><input type="checkbox"/></div> <div>FW Blank</div>	SDFW-901C	Equipment filter wipe blank	Within Site Boundary												<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>							
<div><input type="checkbox"/></div> <div>SJNE013</div>	SJNE013-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE014</div>	SJNE014-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE015</div>	SJNE015-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE016</div>	SJNE016-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE017</div>	SJNE017-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE018</div>	SJNE018-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE019</div>	SJNE019-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE020</div>	SJNE020-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE020</div>	SJNE020-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>FW Blank</div>	SDFW-902S	Equipment filter wipe blank	Within Site Boundary												<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>							
<div><input type="checkbox"/></div> <div>SJNE021</div>	SJNE021-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>			<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE022-1</div>	SJNE022-GR1	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>																
<div><input type="checkbox"/></div> <div>SJNE022-2</div>	SJNE022-GR2	Surface grab	Within Site Boundary	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>	<div><input type="checkbox"/></div>																

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b /-10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
<div>☐</div> SJNE022-3	SJNE022-GR3	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE023	SJNE023-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE023	SJNE023-CR1	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>					
<div>☐</div> SJNE024	SJNE024-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE025	SJNE025-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE026	SJNE026-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE027	SJNE027-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE028	SJNE028-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE028	SJNE028	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE029	SJNE029-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE029	SJNE029	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE030	SJNE030-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE030	SJNE030	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>					
<div>☐</div> SJNE031	SJNE031-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE032	SJNE032-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE033	SJNE033-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE033	SJNE033	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>					
<div>☐</div> SJNE034	SJNE034-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE035	SJNE035-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> SJNE035	SJNE035	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>					
<div>☐</div> SJNE036	SJNE036-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE037	SJNE037-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											
<div>☐</div> SJNE038	SJNE038-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>		<div>☐</div>											

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b /-10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
4±2°C	4±2°C	4±2°C	4±2°C	4±2°C	4±2°C	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C				
<div>☐</div> <div>SJNE039</div>	SJNE039-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE040</div>	SJNE040-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-903S	Equipment filter wipe blank	Within Site Boundary											<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>		
<div>☐</div> <div>SJNE041</div>	SJNE041-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE041</div>	SJNE041	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE042</div>	SJNE042-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE042</div>	SJNE042-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE043</div>	SJNE043-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE043</div>	SJNE043	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE044</div>	SJNE044-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE045</div>	SJNE045-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE046</div>	SJNE046-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE047</div>	SJNE047-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE048</div>	SJNE048-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE049</div>	SJNE049-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE050</div>	SJNE050-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE050</div>	SJNE050-CR1	Core	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>					
<div>☐</div> <div>SJNE051</div>	SJNE051-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE052</div>	SJNE052-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE053</div>	SJNE053-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE054</div>	SJNE054-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE055</div>	SJNE055-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE056</div>	SJNE056-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C				
<div>☐</div> <div>SJNE057</div>	SJNE057-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE058</div>	SJNE058-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJNE059</div>	SJNE059-GR1	Surface grab	Within Site Boundary	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-904S	Equipment filter wipe blank	Within Site Boundary											<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>		
<div>☐</div> <div>SJNE060</div>	SJNE060-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE061</div>	SJNE061-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE062</div>	SJNE062-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE062</div>	SJNE062-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE063</div>	SJNE063-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE064</div>	SJNE064-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE065</div>	SJNE065-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE066</div>	SJNE066-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE067</div>	SJNE067-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE068</div>	SJNE068-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE069</div>	SJNE069-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJNE070</div>	SJNE070-GR1	Surface grab	Upstream background	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>	<div>☐</div>										
<div>☐</div> <div>SJSH001</div>	SJSH001-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH001</div>	SJSH001-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-902C	Equipment filter wipe blank	HHRA shoreline											<div>☐</div>	<div>☐</div>	<div>☐</div>			
<div>☐</div> <div>SJSH002</div>	SJSH002-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH002</div>	SJSH002-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH003</div>	SJSH003-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH003</div>	SJSH003-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C				
<div>☐</div> <div>SJSH004</div>	SJSH004-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH004</div>	SJSH004-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH005</div>	SJSH005-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH005</div>	SJSH005-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH005</div>	SJSH005-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH005</div>	SJSH005-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH006</div>	SJSH006-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH006</div>	SJSH006-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH007</div>	SJSH007-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH007</div>	SJSH007-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH008</div>	SJSH008-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH008</div>	SJSH008-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH009</div>	SJSH009-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH009</div>	SJSH009-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH010</div>	SJSH010-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH010</div>	SJSH010-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-903C	Equipment filter wipe blank	HHRA shoreline												<div>☐</div>	<div>☐</div>	<div>☐</div>		
<div>☐</div> <div>SJSH011</div>	SJSH011-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH011</div>	SJSH011-CR1B	Core	HHRA shoreline 6.0 - 12.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH012</div>	SJSH012-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH012</div>	SJSH012-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH013</div>	SJSH013-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH013</div>	SJSH013-CR1B	Core	HHRA shoreline 6.0 - 12.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax. Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C				
<div>☐</div> <div>SJSH014</div>	SJSH014-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH014</div>	SJSH014-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH015</div>	SJSH015-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH015</div>	SJSH015-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH015</div>	SJSH015-CR1B	Core	HHRA shoreline 6.0 - 12.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH015</div>	SJSH015-CR1B	Core	HHRA shoreline 6.0 - 12.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH016</div>	SJSH016-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH016</div>	SJSH016-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH017</div>	SJSH017-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH017</div>	SJSH017-CR1B	Core	HHRA shoreline 6.0 - 12.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH018</div>	SJSH018-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH018</div>	SJSH018-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH019</div>	SJSH019-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH019</div>	SJSH019-CR1B	Core	HHRA shoreline 6.0 - 12.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH020</div>	SJSH020-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH020</div>	SJSH020-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-904C	Equipment filter wipe blank	HHRA shoreline						<div>☐</div>						<div>☐</div>	<div>☐</div>	<div>☐</div>		
<div>☐</div> <div>SJSH021</div>	SJSH021-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH021</div>	SJSH021-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH022</div>	SJSH022-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH022</div>	SJSH022-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH023</div>	SJSH023-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH023</div>	SJSH023-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax, Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b / -10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C				
<div>☐</div> <div>SJSH024</div>	SJSH024-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH024</div>	SJSH024-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH025</div>	SJSH025-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH025</div>	SJSH025-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH025</div>	SJSH025-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH025</div>	SJSH025-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH026</div>	SJSH026-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH026</div>	SJSH026-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH027</div>	SJSH027-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH027</div>	SJSH027-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH028</div>	SJSH028-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH028</div>	SJSH028-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH029</div>	SJSH029-CR1A	Core	HHRA shoreline 0 - 6.0 in	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH029</div>	SJSH029-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH030</div>	SJSH030-CR1A	Core	HHRA shoreline 0 - 6.0 in						<div>☐</div>										
<div>☐</div> <div>SJSH030</div>	SJSH030-CR1B	Core	HHRA shoreline 6.0 - 12.0 in						<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-905C	Equipment filter wipe blank	HHRA shoreline						<div>☐</div>						<div>☐</div>	<div>☐</div>	<div>☐</div>		
<div>☐</div> <div>SJSH031</div>	SJSH031-CR1A	Core	HHRA background	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH031</div>	SJSH031-CR1B	Core	HHRA background						<div>☐</div>										
<div>☐</div> <div>SJSH032</div>	SJSH032-CR1A	Core	HHRA background						<div>☐</div>										
<div>☐</div> <div>SJSH032</div>	SJSH032-CR1B	Core	HHRA background						<div>☐</div>										
<div>☐</div> <div>SJSH033</div>	SJSH033-CR1A	Core	HHRA background	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH033</div>	SJSH033-CR1B	Core	HHRA background						<div>☐</div>										

Table A-3
Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), Percent moisture (ASTM D 2216)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax, Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a	8oz WMG ^a	16oz WMG ^a	Shelby tube	Shelby tube	Shelby tube	Vane	4oz WMG ^a	4oz WMG ^a	4oz WMG ^a	4oz WMG ^a				
4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b /-10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b	4±2°C	4±2°C	Airtight seal, store vertically	Airtight seal, store vertically	Airtight seal, store vertically	- in situ -	4±2°C	4±2°C	4±2°C	4±2°C				
<div>☐</div> <div>SJSH034</div>	SJSH034-CR1A	Core	HHRA background																
<div>☐</div> <div>SJSH034</div>	SJSH034-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH035</div>	SJSH035-CR1A	Core	HHRA background	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH035</div>	SJSH035-CR1A	Core	HHRA background	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH035</div>	SJSH035-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH035</div>	SJSH035-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH036</div>	SJSH036-CR1A	Core	HHRA background																
<div>☐</div> <div>SJSH036</div>	SJSH036-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH037</div>	SJSH037-CR1A	Core	HHRA background	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH037</div>	SJSH037-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH038</div>	SJSH038-CR1A	Core	HHRA background																
<div>☐</div> <div>SJSH038</div>	SJSH038-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH039</div>	SJSH039-CR1A	Core	HHRA background	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH039</div>	SJSH039-CR1B	Core	HHRA background																
<div>☐</div> <div>SJSH040</div>	SJSH040-CR1A	Core	HHRA background																
<div>☐</div> <div>SJSH040</div>	SJSH040-CR1B	Core	HHRA background																
<div>☐</div> <div>FW Blank</div>	SDFW-906C	Equipment filter wipe blank	HHRA background											<div>☐</div>	<div>☐</div>	<div>☐</div>			
<div>☐</div> <div>SJSH041</div>	SJSH041-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH042</div>	SJSH042-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH043</div>	SJSH043-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH044</div>	SJSH044-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH045</div>	SJSH045-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>													
<div>☐</div> <div>SJSH046</div>	SJSH046-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>													

Field Sample Collection Matrix

Station	Sample ID	Sample Type	Sample Group	Chemistry Grab and Core Samples						Geotechnical Cores						Blank Filter Wipes (Whatman Grade 42 filters)			
				Primary			Secondary			Atterberg limits (ASTM D-4318), Specific gravity (ASTM D-854), percent moisture (ASTM D 22.16)	Grain Size	Sediment permeability (ASTM D-5084)	CU Triax, Compressive Strength (ASTM D-4767)	Consolidation Test (ASTM D-2435)	Vane Shear Test (ASTM D-2573)	Metals	Mercury	Dioxins/ Durans	SVOC
				TOC, Metals, Mercury, and Percent Moisture (EPA 160.3)	Grain Size	Dioxins/ Furans	SVOC	VOCs	Archival										
				8oz WMG ^a	16oz WMG ^a	8oz WMG ^a	8oz WMG ^a	2oz WMG ^a	8oz WMG ^a										
				4±2°C	4±2°C	4±2°C/ Deep frozen (-20°C) ^b /-10°C ^c	4±2°C	4±2°C; do not freeze	4±2°C/ Deep frozen (-20°C) ^b										
4±2°C	4±2°C	4±2°C	4±2°C	4±2°C	4±2°C	8oz WMG ^a	16oz WMG ^a	Shelby tube	Shelby tube	Shelby tube	Vane	4oz WMG ^a	4oz WMG ^a	4oz WMG ^a	4oz WMG ^a				
<div>☐</div> <div>SJSH047</div>	SJSH047-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH048</div>	SJSH048-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH049</div>	SJSH049-GR1	Surface grab	ERA shoreline	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>FW Blank</div>	SDFW-9055	Equipment filter wipe blank	ERA shoreline											<div>☐</div>	<div>☐</div>	<div>☐</div>			
<div>☐</div> <div>SJSH050</div>	SJSH050-GR1	Surface grab	ERA background	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH051</div>	SJSH051-GR1	Surface grab	ERA background	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH052</div>	SJSH052-GR1	Surface grab	ERA background	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
<div>☐</div> <div>SJSH052</div>	SJSH052-GR1	Surface grab	ERA background	<div>☐</div>	<div>☐</div>	<div>☐</div>			<div>☐</div>										
				132	132	132	25	25	192	14	14	14	14	14	12	11	11	11	5

Definitions

AG = amber glass

HDPE = high density polyethylene sample bottle

WMG = wide mouth glass

a - The size and number of containers may be modified by the analytical laboratory.

b - Samples will be shipped to the laboratory on ice at $4\pm 2^{\circ}\text{C}$. Once received at the laboratory samples will be stored at -20° Rinsate Blanks ending in S = SS bowls & spoons

c - Extracts will be stored at -10°C.

d - Refer to Table 14 of the QAPP for details on geotechnical core processing.

Station ID

SD = surface grabs

CR = sediment cores

Rinsate Blanks ending in C = Lexan cores

SN = sample number

TG = tag number

Rinsate Blanks ending in C = Lexan cores

* Rinsate Blanks ending in S = SS bowls & spoons

Table A-4
Station Coordinates, Sample Type, Sampling Interval, and Corresponding Analysis

Station Number	Sample Type	Sampling Interval ^a	Analysis	Coordinates ^{b,c}	
				X	Y
Source Stations					
SJGB001	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength	3216697.5	13857564.5
SJGB002	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength	3216845.615	13857759.22
SJGB003	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength	3217175.12	13857907.52
SJGB004	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength; primary COPCs	3217415.283	13857775.2
SJGB005	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength; primary COPCs	3217496.069	13857603.34
SJGB006	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength	3217009.085	13857746.5
SJGB007	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength; primary COPCs	3217427.729	13857346.82
SJGB008	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength; primary COPCs	3217348.582	13857165.75
SJGB009	Geotechnical boring	5-ft intervals. Starting elevation will be based on initial penetration of auger or casing below mudline	Atterberg limits, grain size, moisture content, specific gravity, sediment compressibility, sediment permeability, consolidated undrained triaxial compressive strength	3216878.366	13857329.24
SJVS001	Vane shear	1, 2, 3 feet depths below mudline	Vane shear	3216837.673	13857733.34
SJVS002	Vane shear	1, 2, 3 feet depths below mudline	Vane shear	3217162.082	13857931.76
SJVS003	Vane shear	1, 2, 3 feet depths below mudline	Vane shear	3217412.468	13857746.27
SJVS004	Vane shear	1, 2, 3 feet depths below mudline	Vane shear	3217148.268	13857524.67
SJVS005	Vane shear	1, 2, 3 feet depths below mudline	Vane shear	3217407.129	13857359.48
SJVS006	Vane shear	1, 2, 3 feet depths below mudline	Vane shear	3217211.824	13857242.94
Stations within the Preliminary Site Boundary					
SJNE001	Surface sediment	0-10 cm	Primary COPCs	3215250	13853000
SJNE002	Surface sediment	0-10 cm	Primary COPCs	3214250	13854000
SJNE003	Surface sediment	0-10 cm	Primary COPCs	3215250	13854000
SJNE004	Surface sediment	0-10 cm	Primary COPCs	3216250	13854000
SJNE005	Surface sediment	0-10 cm	Primary COPCs	3217250	13854000
SJNE006	Surface sediment	0-10 cm	Primary COPCs	3214250	13855000
SJNE007	Surface sediment	0-10 cm	Primary COPCs	3215250	13855000
SJNE008	Surface sediment	0-10 cm	Primary COPCs	3216250	13855000
SJNE009	Surface sediment	0-10 cm	Primary COPCs	3217250	13855000
SJNE010	Surface sediment	0-10 cm	Primary COPCs	3216250	13855500
SJNE011	Surface sediment	0-10 cm	Primary COPCs	3216750	13855500
SJNE012	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217250	13855500
SJNE012	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3217250	13855500
SJNE013	Surface sediment	0-10 cm	Primary COPCs	3214250	13856000
SJNE014	Surface sediment	0-10 cm	Primary COPCs	3216750	13856000
SJNE015	Surface sediment	0-10 cm	Primary COPCs	3217250	13856000
SJNE016	Surface sediment	0-10 cm	Primary COPCs	3215250	13856500
SJNE017	Surface sediment	0-10 cm	Primary COPCs	3217250	13856500
SJNE018	Surface sediment	0-10 cm	Primary COPCs	3215250	13857000
SJNE019	Surface sediment	0-10 cm	Primary COPCs	3215750	13857000
SJNE020	Surface sediment	0-10 cm	Primary COPCs	3217750	13857000
SJNE021	Surface sediment	0-10 cm	Primary COPCs	3218250	13857000
SJNE022-1	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217250	13857514

Table A-4
Station Coordinates, Sample Type, Sampling Interval, and Corresponding Analysis

Station Number	Sample Type	Sampling Interval ^a	Analysis	Coordinates ^{b,c}	
				X	Y
SJNE022-2	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217234	13857486
SJNE022-3	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217267	13857486
SJNE023	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217750	13857500
SJNE023	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3217750	13857500
SJNE024	Surface sediment	0-10 cm	Primary COPCs	3218250	13857500
SJNE025	Surface sediment	0-10 cm	Primary COPCs	3218750	13857500
SJNE026	Surface sediment	0-10 cm	Primary COPCs	3216250	13858000
SJNE027	Surface sediment	0-10 cm	Primary COPCs	3216750	13858000
SJNE028	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217250	13858000
SJNE028	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3217250	13858000
SJNE029	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217750	13858000
SJNE029	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3217750	13858000
SJNE030	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3218250	13858000
SJNE030	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3218250	13858000
SJNE031	Surface sediment	0-10 cm	Primary COPCs	3218750	13858000
SJNE032	Surface sediment	0-10 cm	Primary COPCs	3216250	13858500
SJNE033	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3216750	13858500
SJNE033	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3216750	13858500
SJNE034	Surface sediment	0-10 cm	Primary COPCs	3217250	13858500
SJNE035	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217750	13858500
SJNE035	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3217750	13858500
SJNE036	Surface sediment	0-10 cm	Primary COPCs	3218250	13858500
SJNE037	Surface sediment	0-10 cm	Primary COPCs	3218750	13858500
SJNE038	Surface sediment	0-10 cm	Primary COPCs	3214250	13859000
SJNE039	Surface sediment	0-10 cm	Primary COPCs	3215250	13859000
SJNE040	Surface sediment	0-10 cm	Primary COPCs	3215750	13859000
SJNE041	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3216250	13859000
SJNE041	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3216250	13859000
SJNE042	Surface sediment	0-10 cm	Primary COPCs	3216750	13859000
SJNE043	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3217250	13859000
SJNE043	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3217250	13859000
SJNE044	Surface sediment	0-10 cm	Primary COPCs	3217750	13859000
SJNE045	Surface sediment	0-10 cm	Primary COPCs	3218250	13859000
SJNE046	Surface sediment	0-10 cm	Primary COPCs	3218750	13859000
SJNE047	Surface sediment	0-10 cm	Primary COPCs	3215250	13859500
SJNE048	Surface sediment	0-10 cm	Primary COPCs	3215750	13859500
SJNE049	Surface sediment	0-10 cm	Primary COPCs	3216250	13859500
SJNE050	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3216750	13859500
SJNE050	Subsurface sediment (core)	1 ft intervals to 10 feet	Primary COPCs + additional samples for geotechnical	3216750	13859500
SJNE051	Surface sediment	0-10 cm	Primary COPCs	3217250	13859500
SJNE052	Surface sediment	0-10 cm	Primary COPCs	3214250	13860000
SJNE053	Surface sediment	0-10 cm	Primary COPCs	3215250	13860000
SJNE054	Surface sediment	0-10 cm	Primary COPCs	3216250	13860000
SJNE055	Surface sediment	0-10 cm	Primary COPCs	3217250	13860000
SJNE056	Surface sediment	0-10 cm	Primary COPCs	3218250	13860000
SJNE057	Surface sediment	0-10 cm	Primary COPCs	3215250	13861000
SJNE058	Surface sediment	0-10 cm	Primary COPCs	3216250	13861000
SJNE059	Surface sediment	0-10 cm	Primary COPCs	3217250	13861000
Stations within the Preliminary Site Boundary for Additional Characterization of the Impoundment Area					
SJGB004	Surface sediment	0-10 cm	Primary COPCs	3217415.283	13857775.2

Table A-4
Station Coordinates, Sample Type, Sampling Interval, and Corresponding Analysis

Station Number	Sample Type	Sampling Interval ^a	Analysis	Coordinates ^{b,c}	
				X	Y
SIJB005	Surface sediment	0-10 cm	Primary COPCs	3217496.069	13857603.34
SIJB007	Surface sediment	0-10 cm	Primary COPCs	3217427.729	13857346.82
SIJB008	Surface sediment	0-10 cm	Primary COPCs	3217348.582	13857165.75
Upstream Background Stations					
SJNE060	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3211685.476	13859209.22
SJNE061	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3211965.424	13860868.17
SJNE062	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3212345.697	13863121.63
SJNE063	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3207033.213	13860925.82
SJNE064	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3208153.686	13861627.39
SJNE065	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3209970.905	13862765.22
SJNE066	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3208406.851	13866335.44
SJNE067	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3209933.519	13865308.09
SJNE068	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3210363.371	13865018.83
SJNE069	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3211619.353	13868396.73
SJNE070	Surface sediment	0-10 cm	All COPCs (primary and secondary)	3211946.202	13868073.08
Human Health Shoreline Stations					
SJSH001	Surface sediment	0-15 cm	Archive for possible future analysis	3216929.526	13856475.1
SJSH001	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3216929.526	13856475.1
SJSH002	Surface sediment	0-15 cm	Primary COPCs	3217006.859	13856595.72
SJSH002	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217006.859	13856595.72
SJSH003	Surface sediment	0-15 cm	Archive for possible future analysis	3217082.273	13856701.38
SJSH003	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217082.273	13856701.38
SJSH004	Surface sediment	0-15 cm	Primary COPCs	3217164.295	13856804.86
SJSH004	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217164.295	13856804.86
SJSH005	Surface sediment	0-15 cm	Primary COPCs	3217251.264	13856912.76
SJSH005	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217251.264	13856912.76
SJSH006	Surface sediment	0-15 cm	Archive for possible future analysis	3217448.184	13856253.65
SJSH006	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217448.184	13856253.65
SJSH007	Surface sediment	0-15 cm	Primary COPCs	3217531.119	13856353.35
SJSH007	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217531.119	13856353.35
SJSH008	Surface sediment	0-15 cm	Archive for possible future analysis	3217619.462	13856453.3
SJSH008	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217619.462	13856453.3
SJSH009	Surface sediment	0-15 cm	Archive for possible future analysis	3217707.865	13856542.17
SJSH009	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217707.865	13856542.17
SJSH010	Surface sediment	0-15 cm	Primary COPCs	3217802.719	13856643.99
SJSH010	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3217802.719	13856643.99
SJSH011	Surface sediment	0-15 cm	Primary COPCs	3215964.204	13858103.65
SJSH011	Subsurface sediment (core)	15-30 cm	Primary COPCs	3215964.204	13858103.65
SJSH012	Surface sediment	0-15 cm	Archive for possible future analysis	3215984.431	13858197.5
SJSH012	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3215984.431	13858197.5
SJSH013	Surface sediment	0-15 cm	Primary COPCs	3216017.938	13858285.93
SJSH013	Subsurface sediment (core)	15-30 cm	Primary COPCs	3216017.938	13858285.93
SJSH014	Surface sediment	0-15 cm	Archive for possible future analysis	3216078.173	13858350.31
SJSH014	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3216078.173	13858350.31
SJSH015	Surface sediment	0-15 cm	Primary COPCs	3216160.313	13858391.68
SJSH015	Subsurface sediment (core)	15-30 cm	Primary COPCs	3216160.313	13858391.68
SJSH016	Surface sediment	0-15 cm	Archive for possible future analysis	3216165.738	13858483.69
SJSH016	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3216165.738	13858483.69
SJSH017	Surface sediment	0-15 cm	Primary COPCs	3216129.516	13858569.21
SJSH017	Subsurface sediment (core)	15-30 cm	Primary COPCs	3216129.516	13858569.21

Table A-4
Station Coordinates, Sample Type, Sampling Interval, and Corresponding Analysis

Station Number	Sample Type	Sampling Interval ^a	Analysis	Coordinates ^{b,c}	
				X	Y
SJSH018	Surface sediment	0-15 cm	Archive for possible future analysis	3216100.593	13858654.87
SJSH018	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3216100.593	13858654.87
SJSH019	Surface sediment	0-15 cm	Primary COPCs	3216069.058	13858742.79
SJSH019	Subsurface sediment (core)	15-30 cm	Primary COPCs	3216069.058	13858742.79
SJSH020	Surface sediment	0-15 cm	Archive for possible future analysis	3216023.195	13858821.01
SJSH020	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3216023.195	13858821.01
SJSH021	Surface sediment	0-15 cm	Primary COPCs	3215073.274	13858888.07
SJSH021	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3215073.274	13858888.07
SJSH022	Surface sediment	0-15 cm	Archive for possible future analysis	3215009.754	13858862.52
SJSH022	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3215009.754	13858862.52
SJSH023	Surface sediment	0-15 cm	Primary COPCs	3214944.409	13858841.97
SJSH023	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214944.409	13858841.97
SJSH024	Surface sediment	0-15 cm	Archive for possible future analysis	3214879.12	13858821.24
SJSH024	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214879.12	13858821.24
SJSH025	Surface sediment	0-15 cm	Primary COPCs	3214817.508	13858791.46
SJSH025	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214817.508	13858791.46
SJSH026	Surface sediment	0-15 cm	Archive for possible future analysis	3214756.239	13858760.82
SJSH026	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214756.239	13858760.82
SJSH027	Surface sediment	0-15 cm	Primary COPCs	3214690.833	13858746.95
SJSH027	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214690.833	13858746.95
SJSH028	Surface sediment	0-15 cm	Archive for possible future analysis	3214622.403	13858749.87
SJSH028	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214622.403	13858749.87
SJSH029	Surface sediment	0-15 cm	Primary COPCs	3214553.983	13858753.16
SJSH029	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214553.983	13858753.16
SJSH030	Surface sediment	0-15 cm	Archive for possible future analysis	3214485.569	13858756.6
SJSH030	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3214485.569	13858756.6
Human Health Upstream Background Stations					
SJSH031	Surface sediment	0-15 cm	Primary COPCs	3211913.425	13867187.14
SJSH031	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3211913.425	13867187.14
SJSH032	Surface sediment	0-15 cm	Archive for possible future analysis	3211870.023	13867360.74
SJSH032	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3211870.023	13867360.74
SJSH033	Surface sediment	0-15 cm	Primary COPCs	3211870.023	13867571.55
SJSH033	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3211870.023	13867571.55
SJSH034	Surface sediment	0-15 cm	Archive for possible future analysis	3211888.624	13867763.75
SJSH034	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3211888.624	13867763.75
SJSH035	Surface sediment	0-15 cm	Primary COPCs	3211981.627	13867931.16
SJSH035	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3211981.627	13867931.16
SJSH036	Surface sediment	0-15 cm	Archive for possible future analysis	3212093.23	13868024.16
SJSH036	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3212093.23	13868024.16
SJSH037	Surface sediment	0-15 cm	Primary COPCs	3212254.434	13868067.56
SJSH037	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3212254.434	13868067.56
SJSH038	Surface sediment	0-15 cm	Archive for possible future analysis	3212428.039	13868086.16
SJSH038	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3212428.039	13868086.16
SJSH039	Surface sediment	0-15 cm	Primary COPCs	3212595.444	13868154.37
SJSH039	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3212595.444	13868154.37
SJSH040	Surface sediment	0-15 cm	Archive for possible future analysis	3212775.249	13868247.37
SJSH040	Subsurface sediment (core)	15-30 cm	Archive for possible future analysis	3212775.249	13868247.37
ERA Shoreline Stations					
SJSH041	Surface sediment	0-10 cm	Primary COPCs	3217541.593	13854996.94
SJSH042	Surface sediment	0-10 cm	Primary COPCs	3217670.955	13855163.26

Table A-4
Station Coordinates, Sample Type, Sampling Interval, and Corresponding Analysis

Station Number	Sample Type	Sampling Interval ^a	Analysis	Coordinates ^{b,c}	
				X	Y
SJSH043	Surface sediment	0-10 cm	Primary COPCs	3217750	13855500
SJSH044	Surface sediment	0-10 cm	Primary COPCs	3216426.438	13857546.85
SJSH045	Surface sediment	0-10 cm	Primary COPCs	3216247.071	13857633.82
SJSH046	Surface sediment	0-10 cm	Primary COPCs	3216051.398	13857688.17
SJSH047	Surface sediment	0-10 cm	Primary COPCs	3218393.432	13858467.41
SJSH048	Surface sediment	0-10 cm	Primary COPCs	3218250.671	13858778.06
SJSH049	Surface sediment	0-10 cm	Primary COPCs	3217970.303	13858999.89
ERA Upstream Background Stations					
SJSH050	Surface sediment	0-10 cm	Primary COPCs	3210669.126	13862626.22
SJSH051	Surface sediment	0-10 cm	Primary COPCs	3210582.869	13862777.65
SJSH052	Surface sediment	0-10 cm	Primary COPCs	3210540.493	13862924.24

Notes

COPC = chemical of potential concern

a - 0-10 cm = 0-4 in.; 0-15 cm = 0-6 in.; 15-30 cm = 6-12 in.; 30 cm = 1 ft; 60 cm = 2 ft; 90 cm = 3 ft; 150 cm = 5 ft

b - NAD 1983; State Plane Texas South Central FIPS 4204; US ft

c - Coordinates provided correspond to proposed station locations represented on Figures A-2, A-3, A-4, and A-5. Coordinates for actual station locations will be collected in the field.

Table A-5
Geotechnical Borings with Sample Specifications

Sample ID	Depth Interval ^a (ft)	SPT-N	Moisture Content	Grain Size ^b	Atterberg Limits ^b	Specific Gravity ^b	Permeability ^{b,c}	CuTriax ^{b,c}	Consolidation ^{b,c}
Locations SJGB003 and SJGB007: 120-ft deep boring (in-water geotech location)									
S1	0-1.5	X	X	--	--	--	--	--	--
S2	2.5 - 4.0	X	X	X	--	--	--	--	--
S3	5.0 - 7.0	--	X	--	X	--	--	X	X
S4	7.5 - 9.0	X	X	--	--	--	--	--	--
S5	10.0 - 11.5	X	X	--	X	X	--	--	--
S6	15.0 - 16.5	X	X	X	--	--	--	--	--
S7	20.0 - 21.5	X	X	--	--	--	--	--	--
S8	25.0 - 26.5	X	X	--	X	--	--	--	--
S9	30.0 - 31.5	X	X	X	--	--	--	--	--
S10	35.0 - 36.5	X	X	--	--	--	--	--	--
S11	40.0 - 42.0	--	X	--	X	--	--	--	X
S12	45.0 - 46.5	X	X	X	--	--	--	--	--
S13	50.0 - 51.5	X	X	--	--	--	--	--	--
S14	55.0 - 56.5	X	X	--	X	X	--	--	--
S15	60.0 - 61.5	X	X	X	--	--	--	--	--
S16	65.0 - 66.5	X	X	--	X	--	--	--	--
S17	70.0 - 71.5	X	X	--	X	X	--	--	--
S18	75.0 - 76.5	X	X	X	--	--	--	--	--
S19	80.0 - 81.5	X	X	--	--	--	--	--	--
S20	85.0 - 86.5	X	X	--	X	--	--	--	--
S21	90.0 - 91.5	X	X	X	--	--	--	--	--
S22	95.0 - 96.5	X	X	--	--	--	--	--	--
S23	100.0 - 101.5	X	X	--	X	--	--	--	--
S24	105.0 - 106.5	X	X	X	--	--	--	--	--
S25	110.0 - 111.5	X	X	--	--	--	--	--	--
S26	115.0 - 116.5	X	X	--	X	X	--	--	--
S27	120.0 - 121.5	X	X	X	--	--	--	--	--
Locations SJGB001, SJGB002, SJGB004, SJGB005, and SJGB008: 60-ft deep boring (in-water/on-land geotech location)									
S1	0-1.5	X	X	--	--	--	--	--	--
S2	2.5 - 4.0	X	X	X	--	--	--	--	--
S3	5.0 - 7.0	--	X	--	X	--	--	X	X
S4	7.5 - 9.0	X	X	--	--	--	--	--	--
S5	10.0 - 11.5	X	X	--	X	X	--	--	--
S6	15.0 - 16.5	X	X	X	--	--	--	--	--
S7	20.0 - 21.5	X	X	--	--	--	--	--	--
S8	25.0 - 26.5	X	X	--	X	--	--	--	--
S9	30.0 - 31.5	X	X	X	--	--	--	--	--
S10	35.0 - 36.5	X	X	--	--	--	--	--	--
S11	40.0 - 41.5	--	X	--	X	--	--	--	X
S12	45.0 - 46.5	X	X	X	--	--	--	--	--
S13	50.0 - 51.5	X	X	--	--	--	--	--	--
S14	55.0 - 56.5	X	X	--	X	X	--	--	--
S15	60.0 - 61.5	X	X	X	--	--	--	--	--
Locations SJGB006 and SJGB009: 30-ft deep boring (former waste pit geotech location)									
S1	0-1.5	X	X	--	--	--	--	--	--
S2	2.5 - 4.0	--	X	X	X	--	X	--	--
S3	5.0 - 7.0	--	X	--	--	--	--	X	X
S4	7.5 - 9.0	--	X	--	X	--	X	--	--
S5	10.0 - 11.5	X	X	--	X	X	--	--	--
S6	15.0 - 16.5	X	X	X	--	--	--	--	--

Table A-5
Geotechnical Borings with Sample Specifications

Sample ID	Depth Interval ^a (ft)	SPT-N	Moisture Content	Grain Size ^b	Atterberg Limits ^b	Specific Gravity ^b	Permeability ^{b,c}	CuTriax ^{b,c}	Consolidation ^{b,c}
S7	20.0 - 21.5	X	X	--	--	--	--	--	--
S8	25.0 - 26.5	X	X	--	X	--	--	--	--
S9	30.0 - 31.5	X	X	X	--	--	--	--	--

Notes

-- = NA

CuTriax = consolidated undrained triaxial test

SPT-N = standard penetration test blow counts

a - Depth interval will be set in the field depending on the starting depth of the auger. All depths relative to ground surface or mudline.

b - Actual physical testing depth interval will be determined in the field based on the geologic interpretation of conditions encountered.

c - Permeability, CuTriax and consolidation testing to be performed on undisturbed Shelby tubes collected from appropriate depth intervals in the field as determined by the field geologist.

Table A-6
Physical Testing Data Relevant to Dredging, Materials Handling, and/or Confined Disposal Facility (CDF) Design

	Engineering Evaluations Testing										
	Standard Penetration Test	Thin-Walled Tube Collection	Vane Shear Test	Atterberg Limits	Grain Size	Specific Gravity	Moisture Content	Visual Description	Permeability	Consolidated Undrained Triaxial Compressive Strength	Consolidation Test
	(ASTM D-1586)	(ASTM D-1587)	(ASTM D-2573)	(ASTM D-4318)	(ASTM D-422 & D-1140)	(ASTM D-854)	(ASTM D-2216)	(ASMTD-2488)	(ASTM D-5084)	(ASTM D-4767)	(ASTM D-2435)
Dredging and Handling											
Hydraulic Dredging and Materials Handling	--	--	--	X	X	X	X	X	--	--	--
CDF and Berm Design											
Soil Classification	X	X	--	X	X	X	X	X	X	--	--
Soil Strength	X	X	X	--	--	--	--	--	--	X	--
Soil Compressibility	--	X	--	--	--	--	--	--	--	--	X

Notes

-- = NA

Table A-7
Vane Shear Test and Co-Located Surface Grab Sampling Design

Station ID	Proposed Coordinates ^{a,b}	Sample Method	Sampling Depth (ft) ^{c,d}	Sample Method	Sampling Depth (ft) ^e	Physical Tests
SJ-VST01	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST02	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST03	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST04	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST05	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG
SJ-VST06	TBD	VST	0-1, 1-2, 2-3	Surface grab	0-1	GS, MC, AL, SG

Notes

Sediment surface grabs will be co-located with VST locations to facilitate standardization of the field vane shear measurements.

TBD = to be determined

VST = vane shear test

a - Coordinates will be determined based on finalization of sampling locations.

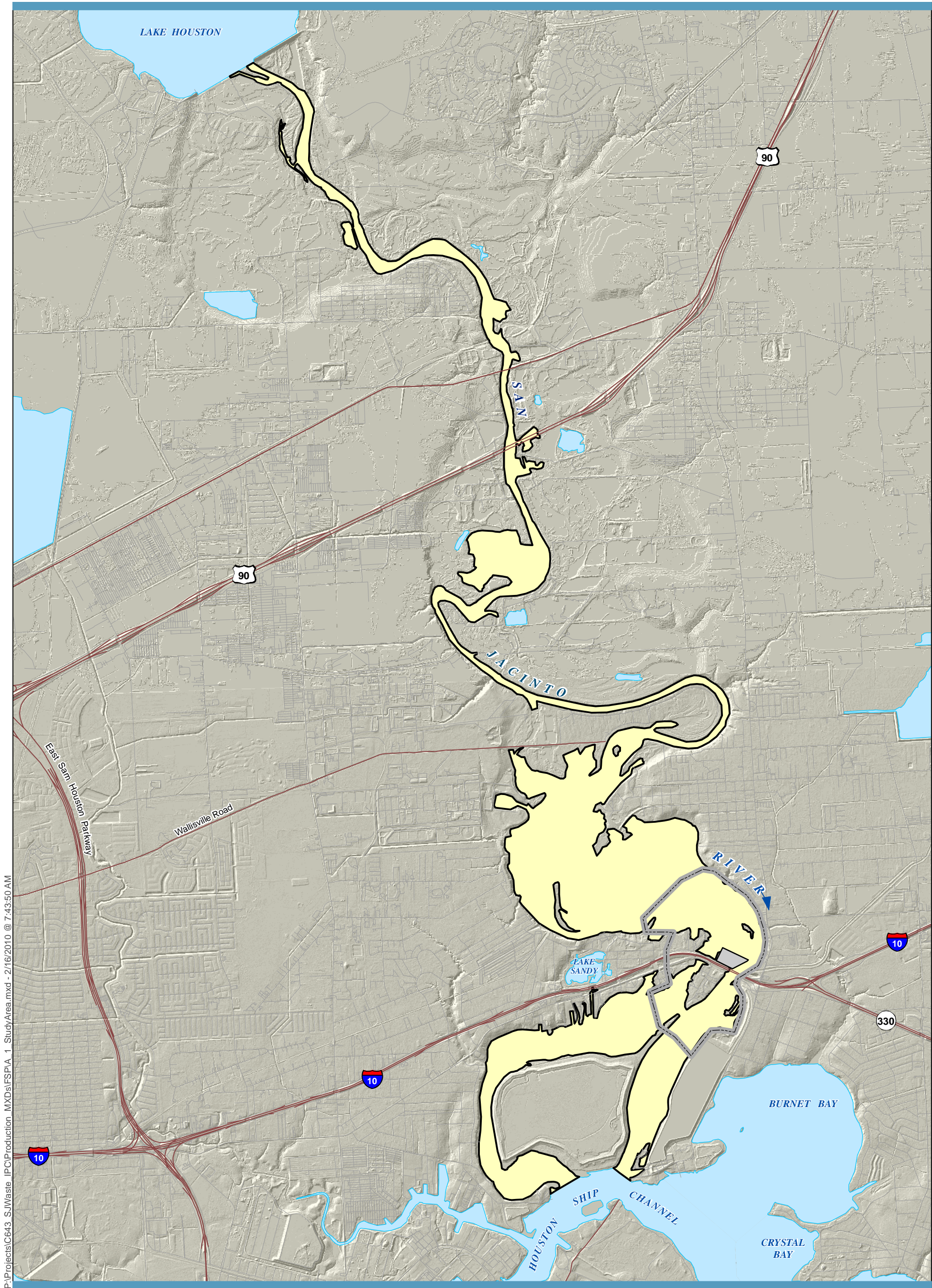
b - Physical testing: GS = grain size, MC = moisture content, AL = Atterberg limits, SG = specific gravity

c - VST to be performed at the following depth intervals below mudline: 0-1, 1-2, and 2-3 ft.

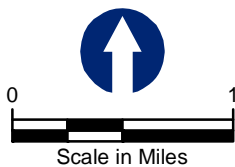
d - Both peak and residual VST strength to be measured at each depth interval.

e - Sample depth refers to surface grabs, not to the VST depth.

FIGURES



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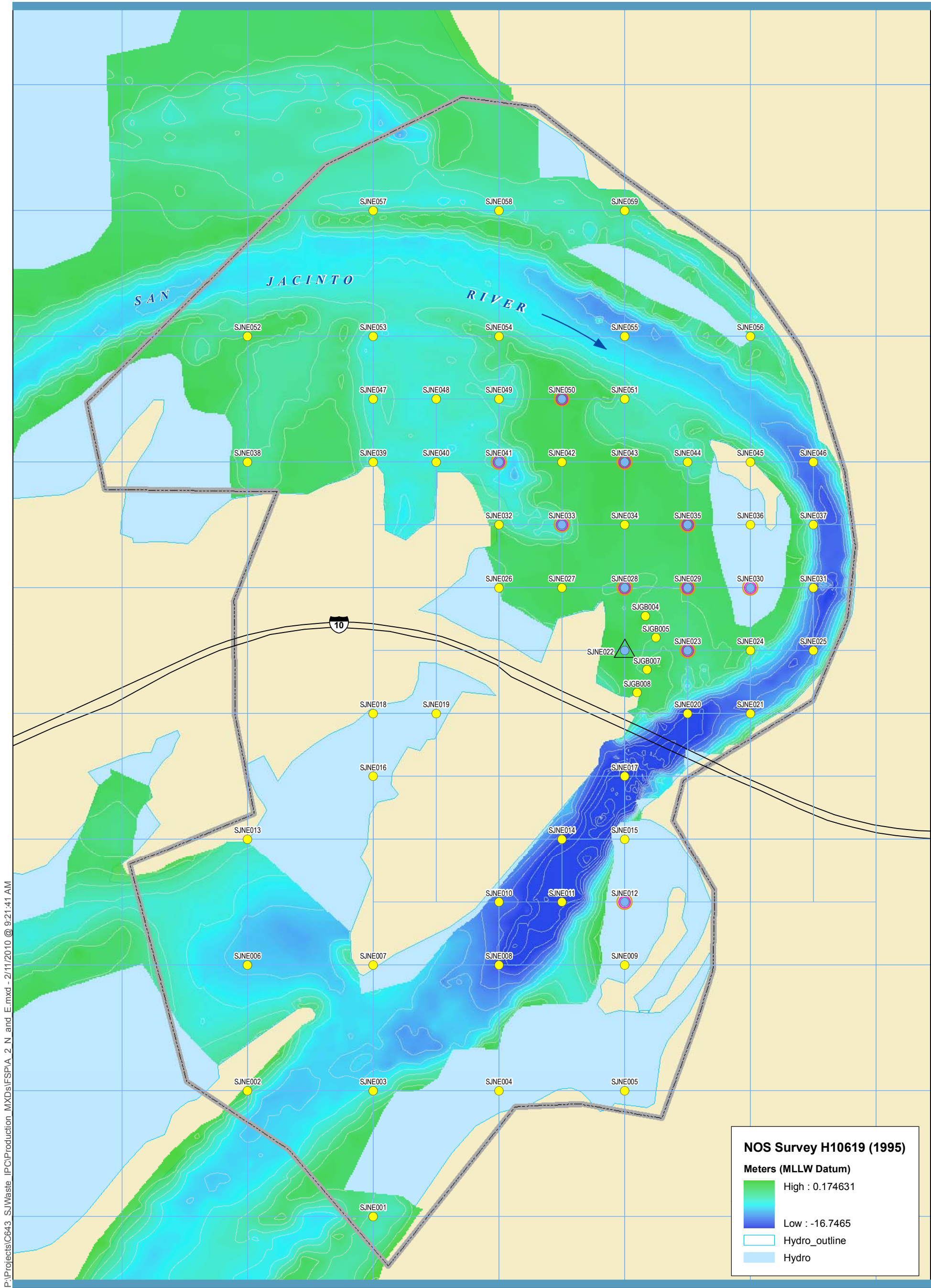


- Preliminary Site Perimeter
- Virgil C. McGinnes Trustee Parcel
- Study Area

FEATURE SOURCES:
Hydrology: Harris County Flood Control District
Transportation Lines: OpenStreetMap
Elevation Hillshade: USGS 3m DEM

Figure A-1
Study Area Overview
SJRWP Sediment FSP
SJRWP Superfund/MIMC and IPC

DRAFT
DO NOT QUOTE OR CITE



Preliminary Site Perimeter



1-Meter 1995 Bathymetric Contour



Field Triplicate

Proposed Locations

- Surface Sediment (Primary and Secondary COPCs)
- Surface Sediment (Primary COPCs)
- Surface Sediment (Primary and Secondary COPCs) and Core (Primary COPCs)
- Additional Geotechnical Samples From Core

Figure A-2

Nature and Extent Sediment Sampling
Locations Within the Preliminary Site Perimeter
SJRW Sediment FSP
SJRW Superfund/MIMC and IPC

DRAFT

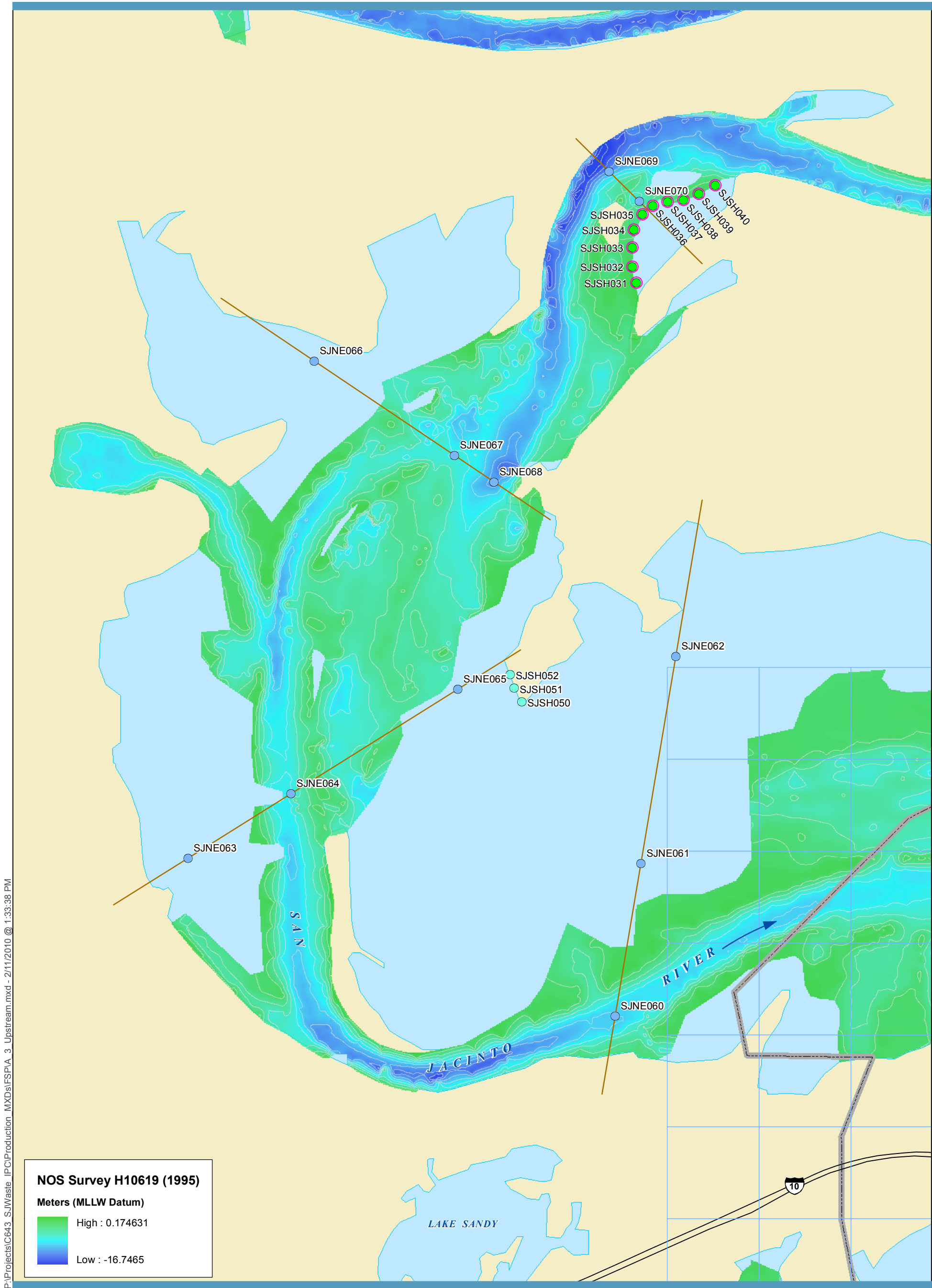
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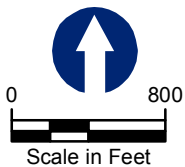
0 800

Scale in Feet

FEATURE SOURCES:
Bathymetry and Contours: NOS Survey H1016 (1995)



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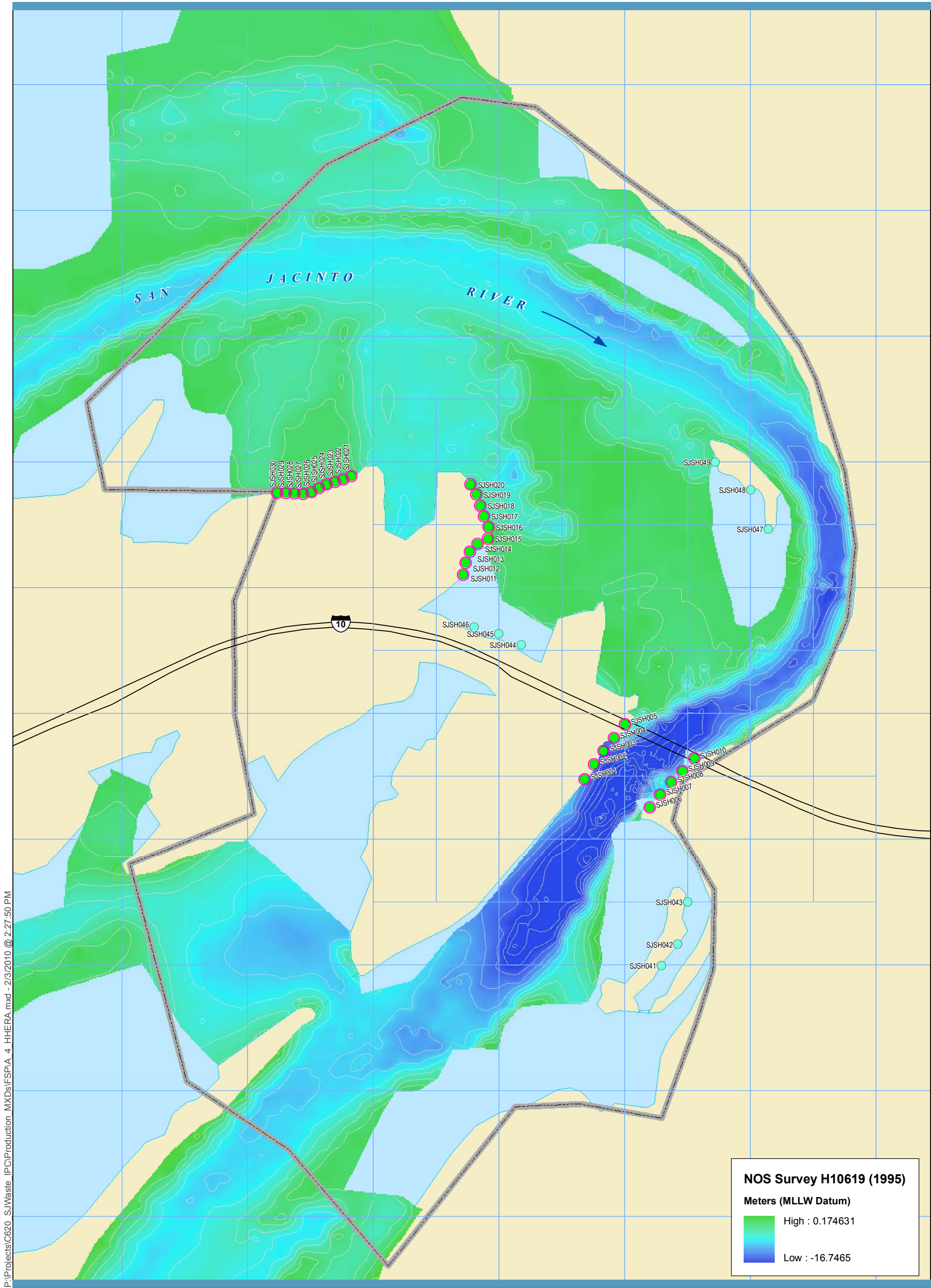
FEATURE SOURCES:
 Bathymetry and Contours: NOS Survey H1016 (1995)

- Preliminary Site Perimeter
- 1-Meter 1995 Bathymetric Contour
- Sampling Transect

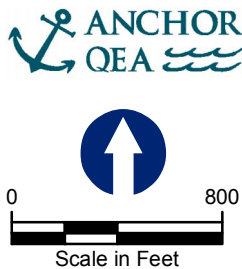
- Proposed Locations**
- Human Health Surface Sediment (Primary COPCs)
 - Human Health Surface Sediment and Subsurface Sediment (Primary COPCs)
 - Upstream Background (Primary and Secondary COPCs)
 - ERA (Primary COPCs)

Figure A-3
 Upstream Sediment Sampling Locations
 SJRWP Sediment FSP
 SJRWP Superfund/MIMC and IPC

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FEATURE SOURCES:
Bathymetry and Contours: NOS Survey H1016 (1995)

- Proposed Locations**
- Human Health Surface Sediment (Primary COPCs)
 - Human Health Surface Sediment and Subsurface Sediment (Primary COPCs)
 - ERA Surface Sediment (Primary COPCs)

Figure A-4

Human Health and Ecological Exposure Sediment Sampling Locations Within the Preliminary Site Perimeter

SJRWP Sediment FSP

SJRWP Superfund/MIMC and IPC

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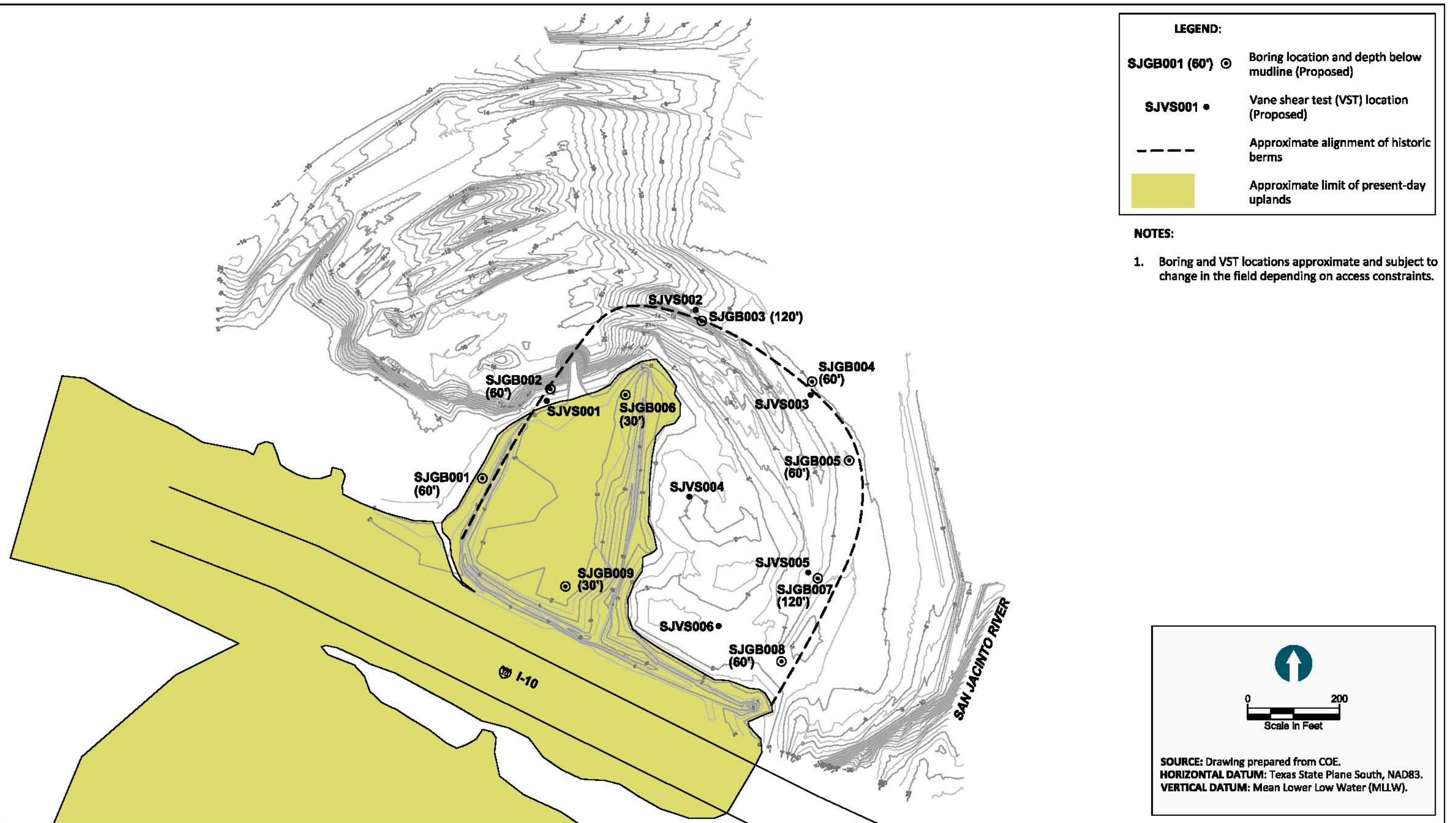


Figure A-5
Proposed Geotechnical Borings and
Vane Shear Test Locations
San Jacinto Island

ATTACHMENT A1

DRAFT ADDENDUM 1 TO THE OVERALL HEALTH AND SAFETY PLAN: SEDIMENT SAMPLING HEALTH AND SAFETY PLAN

Prepared for

McGinnes Industrial Maintenance Corporation
International Paper Company

Prepared by

Integral Consulting Inc.
411 First Avenue South, Suite 550
Seattle, Washington 98104

February 2010

CERTIFICATION PAGE

Addendum 1 to the overall health and safety plan (HASP; Anchor QEA 2009) for the San Jacinto River Waste Pits Superfund Site (the Site) has been reviewed and approved by Integral Consulting Inc. (Integral) for the 2010 sediment study at the Site in support of the remedial investigation and feasibility study (RI/FS) for the Site.

Jennifer Sampson
Project Manager
Integral Consulting Inc.

Date: _____

Joss Moore
Field Lead
Integral Consulting Inc.

Date: _____

HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT FORM

Project Name: San Jacinto River Waste Pits Superfund Site

Addendum 1 to the overall HASP (Anchor QEA 2009) is approved by Integral for use at the San Jacinto River Waste Pits Superfund Site (the Site). The overall HASP and Addendum 1 are the minimum health and safety standard for the Site and will be strictly enforced for Integral personnel and other consulting personnel including subcontractors where applicable.

I have reviewed Addendum 1, dated February 17, 2010, to the overall HASP for the 2010 sediment study. I have had an opportunity to ask any questions I may have and have been provided with satisfactory responses. I understand the purpose of the plan, and I consent to adhere to its policies, procedures, and guidelines while an employee of Integral, or its subcontractors.

Date	Name (print)	Signature	Company

[illegible]

SITE EMERGENCY PROCEDURES

Emergency Contact Information

Table A
Site Emergency Form and Emergency Phone Numbers

Category	Information
Chemicals of Potential Concern	Dioxins/Furans, aluminum, magnesium, mercury, and copper
Minimum Level of Protection	Level D
Site(s) Location Address	(No formal address, see Figure A) Channelview, TX 77530 Coordinates [29° 47' 38.49"N, 95° 3' 49.55"W]
Emergency Phone Numbers	
Ambulance	911
Fire	911
Police	911
Poison Control	911 and then 1-800-222-1212 if appropriate
Project-Specific Health and Safety Officers' Phone Numbers	
Integral Field Lead (FL) and Integral Site Safety Officer (SSO)	Joss Moore Office: (503) 284-5545 ext. 17 Cell: (503) 320-1796
Integral Corporate Health and Safety Manager (CHSM)	Eron Dodak Office: (503) 284-5545 ext. 14 Cell: (503) 407-2933
Integral Project Manager (PM)	Jennifer Sampson Office: (206) 957-0351 Cell: (360) 286-7552
Anchor QEA PM	David Keith Office: (228) 818-9626 Cell: (228) 224-2983
Anchor QEA FL and SSO	Jason Kase Office: (850) 912-8400 Cell: (251) 259-7196
Anchor QEA CHSM	David Templeton Office: (206) 287-9130 Cell: (206) 910-4279
Client Contact – McGinnes Industrial Maintenance Corporation (MIMC)	Andrew Shafer Office: (713) 647-5460 Cell: (832) 724-3802
Client Contract – International Paper Company (IPC)	Phil Slowiak Office: (901) 419-3845 Cell: (901) 214-9550
Reporting Oil and Chemical Spills	
National Response Center	1-800-424-8802
State Emergency Response System	(512) 424-2138
EPA Environmental Response Team	(201) 321-6600

Note: In the event of any emergency, contact both the Integral and Anchor QEA PMs and FLs.

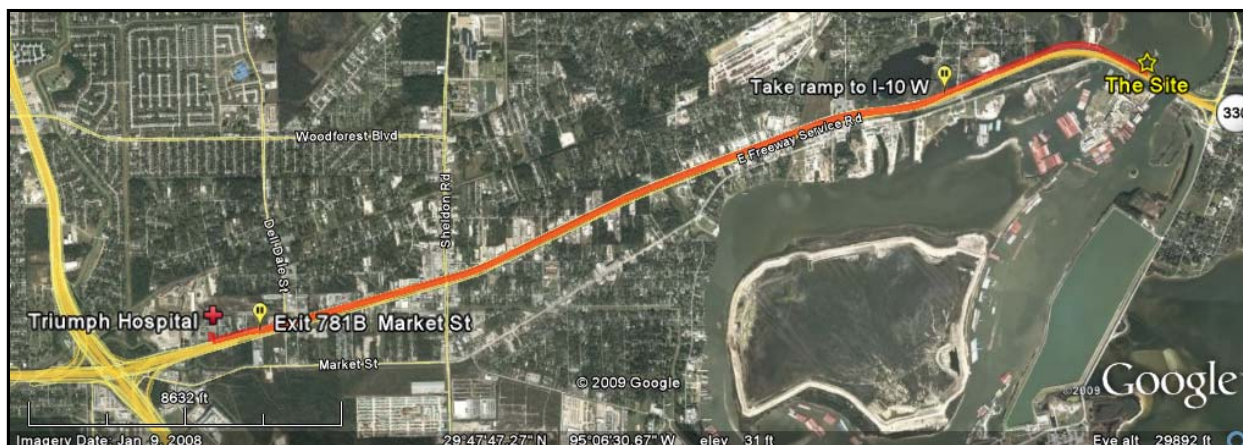
Figure A
Site Location Map



Table B
Hospital Information

Category	Information
Hospital Name	Triumph Hospital – East Houston
Address	15101 East Freeway
City, State	Channelview, TX 77530-41041
Phone	(713) 691-6556
Emergency Phone	(713) 691-6556

Figure B
Hospital Route Map



DRIVING DIRECTIONS FROM SITE TO HOSPITAL

1. Head west on East Freeway Service Road toward Monmouth Street (approximately 0.9 mile).
2. Take the ramp on the left to I-10 West.
3. Proceed on I-10 West to Exit 781B (approximately 3.7 miles).
4. Exit freeway at Exit 781B onto East Freeway Service Road.
5. Continue heading west on East Freeway Service Road (approximately 0.2 mile).
6. Triumph Hospital will be on the right (total distance approximately 5 miles).

Figure C
Access from Site to I-10 West

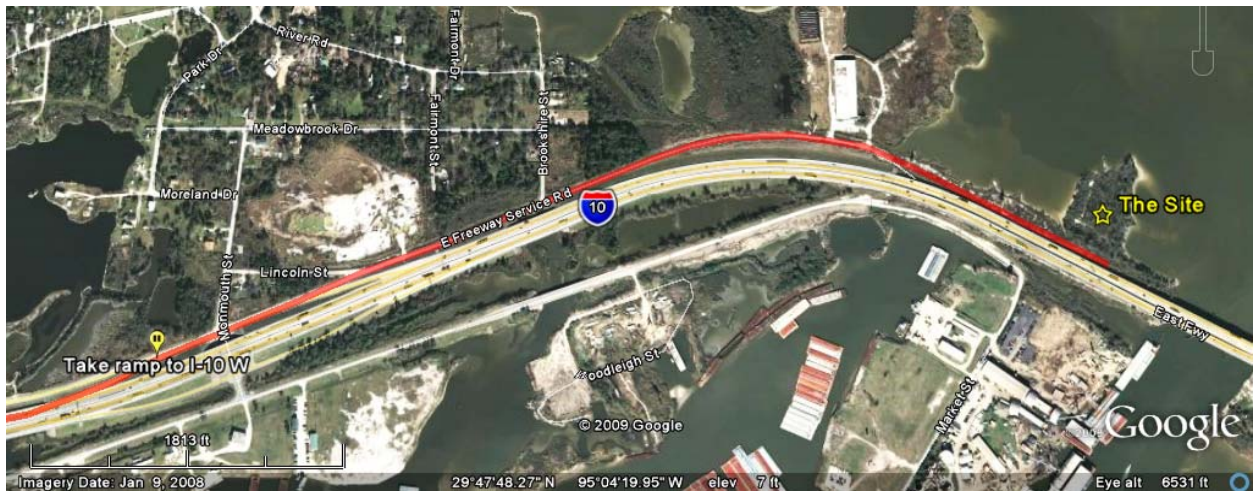


Figure D
Hospital Detail (Egress from I-10 West)



Emergency Response Procedures

In the event of an emergency, refer to the procedures in the San Jacinto River Waste Pits Superfund Site Overall HASP (Anchor QEA 2009).

A copy of this Addendum must be included with the overall HASP, and both copies must be available in the field at all times during field work.

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List of Exhibits

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
°F	degrees Fahrenheit
ACGIH	American Conference of Governmental Industrial Hygienists
Anchor QEA	Anchor QEA, LLC
AWG	American Wire Gauge
CHSM	Corporate Health and Safety Manager
COPC	chemical of potential concern
CRZ	contamination reduction zone
FL	Field Lead
HASP	Health and Safety Plan
Integral	Integral Consulting Inc.
IPC	International Paper Company
JHA	Job Hazard Analysis
MIMC	McGinnes Industrial Maintenance Corporation
mg/m ³	milligrams per cubic meter
MSDS	Material Safety Data Sheets
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Act or Administration
PEL	Permissible Exposure Limit
PDF	personal flotation device
PM	Project Manager
PPE	personal protective equipment
ppm	parts per million
RI/FS	remedial investigation and feasibility study
Site	San Jacinto River Waste Pits Superfund Site
SJRWP	San Jacinto River Waste Pits
SSO	Site Safety Officer
STEL	Short Term Exposure Limit
TLV	Threshold Limit Values
TWA	Time Weighted Average
USEPA	U.S. Environmental Protection Agency

1 INTRODUCTION

Integral Consulting Inc. (Integral) has prepared Addendum 1 to the San Jacinto River Waste Pits Superfund (SJRWSP) Site (the Site) overall Health and Safety Plan (HASP; Anchor QEA 2009). This addendum provides study-specific information and health and safety provisions to protect workers from potential hazards during sediment sampling activities at locations in the impoundment area and within the San Jacinto River. Site background information and general health and safety provisions to protect workers from potential hazards during work at the Site are presented in the overall HASP.

The provisions of this Sediment Sampling HASP are mandatory for all Integral, Anchor QEA, and any contractor personnel assigned to the project. Other contractors that will be working at the Site are also expected to follow the provisions of this Sediment Sampling HASP unless they have their own HASP that covers their specific activities related to this study and such HASPs have been approved by Integral. Any other contractor HASPs must include the requirements set forth in this Sediment Sampling HASP and the overall HASP (Anchor QEA 2009), at a minimum. All visitors to the work Site, including U.S. Environmental Protection Agency (USEPA) personnel; state and local government personnel; or employees, representatives, or contractors of McGinnes Industrial Maintenance Corporation (MIMC) and Industrial Paper Company (IPC) must also abide by the requirements of this Sediment Sampling HASP and will attend a pre-work briefing where the contents of this Sediment Sampling HASP and the overall HASP (Anchor QEA 2009) will be presented and discussed.

It is Integral's policy to provide a safe and healthful work environment. No aspect of the work is more important than protecting the health and safety of all workers.

Integral cannot guarantee the health or safety of any person entering the Site. Because of the potentially hazardous nature of the Site and the activity occurring thereon, it is not possible to regulate personal diligence or to discover, evaluate, and provide protection for all possible hazards that may be encountered. Strict adherence to the health and safety guidelines set forth herein and in the overall HASP (Anchor QEA 2009) will reduce, but not eliminate, the potential for injury and illness at the Site. The health and safety guidelines in this plan were

prepared specifically for the Site and should not be used on any other site without prior evaluation by trained health and safety personnel.

A copy of this Sediment Sampling HASP (Addendum 1) and the overall HASP (Anchor QEA 2009) must be in the custody of the field crew during field activities. All individuals performing field work must read, understand, and comply with these plans before undertaking field activities. Once the information has been read and understood, the individual must sign the Site Health and Safety Acknowledgment Form provided with this Sediment Sampling HASP. The signed form will become part of Integral and Anchor QEA, LLC (Anchor QEA) project files (as applicable to each company).

Addendum 1, this Sediment Sampling HASP, may be modified at any time based on the judgment of either Integral's or Anchor QEA's Site Safety Officer (SSO) in consultation with Integral's or Anchor QEA's Corporate Health and Safety Manager (CHSM) and Project Manager or designee. Any modification will be presented to the on-site team during a safety briefing and will be recorded in the field notebook.

2 SCOPE OF WORK

To perform the field work required for the 2010 sediment study, two field sampling teams will be deployed: one team from Integral and one team from Anchor QEA. The following tasks will be performed by the two teams using this Sediment Sampling HASP:

- Integral team:
 - Collection of surface and subsurface sediment for chemical analyses within the San Jacinto River
 - Collection of surface and subsurface nearshore, intertidal sediment (to the lowest low water level at time of sampling) along the shoreline of the San Jacinto River.
- Anchor QEA team:
 - Collection of sediment borings for measurements of geotechnical and engineering properties within the Site and also from the San Jacinto River
 - Collection of vane shear test information.

The Integral team will collect surface sediment samples in the nearshore, intertidal areas using a decontaminated, stainless-steel spade, shovel, or a modified Petit Ponar grab (or equivalent kind of equipment). Subsurface sediment in the nearshore, intertidal areas will be collected with a stainless steel hand corer. Submerged surface sediments in the San Jacinto River will be collected from a boat using either a power grab or a van Veen grab (or equivalent kind of equipment). Subsurface surface sediment cores in the San Jacinto River will be collected using a decontaminated coring device (e.g., vibracorer when sampling from a boat, with Lexan™ liner and core catcher).

The Anchor QEA team will collect sediment borings using Shelby tubes and split-spoon samplers. They will also use vane shear test equipment.

Access to the majority of the stations will require the use of a boat (Integral team) or barge (Anchor QEA team). Depending on water levels, intertidal sediment samples may be collected by sampling personnel equipped with hip- or chest waders, mudders strapped to their boots to prevent sinking while walking in soft sediments, and personal flotation devices (PFDs). Samples at the intertidal area will be collected as safely as possible from the lowest

low water level at time of sampling. If sampling of intertidal stations is not feasible at low tide, then a boat may also be used to collect the nearshore, intertidal samples during high tide.

3 AUTHORITY AND RESPONSIBILITIES OF KEY PERSONNEL

This section describes the authority and responsibilities of key Integral and Anchor QEA project personnel.

Because the Integral and Anchor QEA teams will be working autonomously, each team will have an SSO. To maintain adequate Site control, each SSO will have the authority to enforce the rules of the overall HASP and the Sediment Sampling HASP Addendum 1 to any individual present at the Site, whether that individual is an employee or an outside contractor who is working with his or her team.

Because there is more than one HASP [i.e., overall HASP (Anchor QEA 2009) and the Sediment Sampling HASP (Addendum 1)], the Occupational Safety and Health Act or Administration (OSHA) (OSHA 1997) considers it essential that the plans be integrated and enforced consistently to ensure that on-site personnel have a clear understanding of health and safety expectations, lines of authority, and emergency response actions.

The names and contact information for key safety personnel are listed in the Emergency Site Procedures section at the beginning of this HASP (Table A). Should key Site personnel change during the course of the project, a new list will be established and given immediately to the field teams. The emergency phone number for the Site is **911**, and should be used for all medical, fire, and police emergencies.

Joss Moore and Jason Kase (proposed Integral and Anchor QEA Field Leads [FLs] and SSOs, respectively) have oversight responsibility for all safety and health activities and the authority to discontinue or modify Site operations when unsafe conditions are detected. FLs will be in direct contact with their respective CHSMs (Eron Dodak for Integral and David Templeton for Anchor QEA) and Project Managers (PMs; Jennifer Sampson for Integral and David Keith for Anchor QEA).

The PMs will be in regular contact with their respective FL/SSOs and CHSMs to ensure that appropriate health and safety procedures are implemented during the 2010 sediment study.

Subcontractors that will provide a boat or barge for in-water work will be identified at a later date, and their names and contact information will be distributed with an updated contact list table to all participants.

4 JOB HAZARD ANALYSIS

The OSHA standard (29 CFR 1910.120) mandates that Site safety and health programs require that task- and operation-specific hazard analyses be conducted at the Site. These analyses are intended to ensure a comprehensive and systematic approach to hazard anticipation, recognition, and evaluation at hazardous waste sites.

The kinds of potential hazards associated with sediment sampling are summarized in the Job Hazard Analysis (JHA) that is provided in Table 1 (located at the end of this section of the Sediment Sampling HASP) for the sediment sampling task. The JHA lists a task or operation required during Site activity and the location(s) where that task or operation is performed. A single JHA may be used for a task performed in multiple locations if the hazards, potential exposures, and controls are the same in each location.

The JHA lists the chemical hazards associated with that task and their known or anticipated airborne concentrations during performance of the task. Each JHA also identifies anticipated physical and biological hazards and potential exposure levels or the likelihood of exposure. The final section of each JHA lists the control measures implemented to protect employees from exposure to the identified hazards. The information provided here is designed to satisfy OSHA's hazardous waste operations and emergency response JHA requirements of 1910.120(b)(4)(ii)(A) and the workplace hazard assessment requirements of 1910.132(d).

Health hazard information for all chemicals of potential concern (COPCs) identified in Site JHAs appears in the material safety data sheets (MSDS) of the overall HASP (Anchor QEA 2009).

Integral and Anchor QEA's FL will modify the study-specific JHA when:

- The scope of work is changed by adding, eliminating, or modifying tasks
- New methods of performing study tasks are selected
- Observation of the performance of study tasks results in a revised characterization of the hazards
- New chemical, biological, or physical hazards are identified
- Exposure data indicate changes in the concentration and/or likelihood of exposure

- New/different control measures are selected.

If the JHA is modified, then related provisions in other sections of this Sediment Sampling HASP will also be modified as needed.

The overall hazard level associated with the activities described in Section 2 is low. Hazards encountered during these sampling programs are due to physical safety hazards associated with the field operations, exposure to chemicals used to decontaminate sampling gear and preserve samples, and potential exposure to hazardous materials present within the sediments. Potential hazards while working at the Site include, but are not limited to, the following:

- Exposure to toxic and/or hazardous chemicals
- Physical hazards from use of sampling equipment and operations on a vessel and on land areas
- Physical hazards from working conditions (e.g., hypothermia, slips/trips/falls, or drowning).

As described below, protective equipment and safe working procedures will help prevent accidents caused by these hazards. All workers are required to use the buddy system, and no one will be allowed to work alone.

4.1 Definitions

Chemical hazards are defined by the following terms:

Time-weighted Average (TWA): The recommended exposure limits for a hazardous chemical in the workplace, typically during an 8-hour work day over a 40-hour work week. TWAs are recommended by the National Institute for Occupational Safety and Health (NIOSH) under the authority of OSHA.

Permissible Exposure Limit (PEL): The legal maximum air concentration of a hazardous chemical to which workers may be exposed on an 8-hour basis as established by OSHA. The

PEL is a time-weighted average value (PEL-TWA), and for all chemicals discussed below, the corresponding PEL-TWA is the same for OSHA.

Threshold Limit Value (TLV): The recommended maximum air concentration of a hazardous chemical to which workers may be exposed on an 8-hour basis. TLVs are time-weighted average values (TLV-TWA) and are recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

Short-term Exposure Limit (STEL): A 15-minute TWA exposure that should not be exceeded at any time during a workday.

Ceiling Limit: Employee's exposure, which should not be exceeded during any part of the workday.

Buddy system: "Buddy system" means that an employee is designated to be observed by at least one other employee in the work group. The purpose of the buddy system is to provide rapid assistance to employees in the event of an emergency.

4.2 Chemical Hazards

Table 1 presents a summary of health-based chemical exposure information for the primary COPCs for the 2010 sediment sampling. Additional information (including MSDSs and occupational health guidelines) is provided in Appendix B of the overall HASP (Anchor QEA 2009).

4.2.1 Potential Hazards of COPCs in Sediments

A summary of the COPCs for health and safety and their concentrations in the Site sediments is provided in Table 1. This list includes chemicals that were detected in surface sediment samples: dioxins/furans, aluminum, copper, and mercury. During the sediment sampling, these COPCs will be bound in a wet solid matrix (i.e., the sediment) and pose a low risk for inhalation. Personnel will also be working in an open-air environment. Nonetheless, these compounds are potentially hazardous and exposure by all routes should be minimized. There is no evidence of significant concentrations of volatile chemicals in

sediment or surface water (Anchor QEA 2009). Therefore, respiratory protection is not expected to be needed, and either Level D (off-site sampling handling) or Modified Level D personal protective equipment (PPE) should be appropriate for the entire investigation. MSDSs for these compounds are provided in Appendix B of the general HASP overall (Anchor QEA 2009).

4.3 Physical Hazards

As stated in Section 2 above, it will be necessary to use a variety of boats, barges, and vehicles to access the proposed sediment sampling locations. The sections below provide safety guidelines for the use of boats and vehicles. The different physical hazard that may be associated with each of these operations is discussed below.

4.3.1 Sampling Vessel Operations

The physical hazards associated with the deployment and retrieval of surface and subsurface sampling equipment result from their weight and the method of deployment. Only appropriate personnel whose presence is required will be deploying and retrieving sampling gear. Under circumstances of potentially dangerous waves or winds, the vessel (i.e., boat or barge) operator and FL/SSO will employ best professional judgment to ensure safe field operations.

To avoid injuries from heavy equipment, personnel will wear steel-toed boots when working on the work deck or loading/unloading heavy equipment from the vessel. Due to the proximity of overhead gear, hard hats will be worn when personnel are present on the work deck. Sample handling equipment, containers, deck lines, hydraulic cables, and water hoses not in immediate use will be kept clear of walkways and work areas until needed. Each time operations at a given location have been completed, excess sediment on the deck will be washed overboard to prevent slipping, minimize personnel exposure to potentially contaminated sediment, and limit cross-contamination between sample locations.

PFDs (i.e., life vests) will be provided for and worn by all personnel working on the deck, or as directed by the FL/SSO or vessel operator. The vessel will also be equipped with

throwable life rings, fire extinguishers, and warning horns, and each crew member will be briefed on their storage location.

4.3.2 *Small Craft Operation*

Safety procedures on small boats (i.e., length 20 feet or less) may necessitate an increased level of protection, depending on boat size and location in the river. Small boat procedures will include all the requirements listed above. In addition, all personnel onboard will be required to wear PFDs at all times. Any subcontractors operating small watercraft in the San Jacinto River during sediment sampling must have taken a Coast Guard Auxiliary boating safety course or equivalent and a demonstrated knowledge of the safe handling of these craft.

4.3.3 *Man Overboard*

While any team is working over water on the sampling vessel there is a potential for a man-overboard situation. The danger of this situation is increased if the water is flowing swiftly or if there is debris in the water. All personnel working over water will wear a PFD. If a man-overboard situation occurs, all vessel engines will be stopped immediately.

Flotation devices (e.g., life rings) attached to lines will be thrown to the victim from the vessel. The victim will then be brought aboard the sampling vessel; wet clothes will be removed and replaced with dry clothing. The victim may need to be treated for cold stress (Section 4.3.5). No other person should enter the water unless the victim is unconscious or seriously injured. If required, rescuers must wear PFDs, and be tethered to the sampling vessel or shore.

4.3.4 *Motor Vehicle Operation*

Motor vehicles will be used to transport field personnel, equipment, and supplies to the nearshore, intertidal sampling locations that will be accessed during low tide. Motor vehicles will also be used to transport field personnel, equipment, and supplies to the sampling vessels and sample processing/shipping locations. Only sampling team personnel with valid driver's licenses and liability insurance (per local state laws) will operate motor vehicles required for work activities. All field staff will use best professional judgment at all times to ensure safe operation of motor vehicles, including:

- Operators are to practice defensive driving and drive in a courteous manner
- Operators are to be aware of pedestrians and give them the right-of-way
- All vehicles are to be operated in a safe manner and in compliance with statutory traffic regulations and ordinances
- Operators are to verify that safety seat belts are in proper operating order
- Seat belts are to be worn by the driver and all passengers whenever the vehicle is in motion
- No persons are allowed to ride in the back of any vehicles, unless equipped with seat belts
- Vehicles are to be driven in conformance with local speed limits
- Operators are to avoid excessively long driving periods
- Personnel who are impaired by fatigue, illness, alcohol, illegal or prescription drugs, or who are otherwise physically unfit, are not allowed to drive
- Personnel are to avoid using cellular phones or engaging in other distractions while driving
- Motor vehicle accidents are to be reported to the responsible law enforcement agency, Integral's human resources manager, and Integral's CHSM.

4.3.5 Physical Exposure

Exposure to the elements and fatigue are two major causes of accidents while working outside. The individual task activities may include long work days and unpredictable weather. Working in cold, rough, or swift-moving waters can lead to fatigue, seasickness, and/or overexposure. The combination of vessel motion and fatigue increases the risk for a man-overboard situation.

To prevent fatigue and overexposure in adverse weather conditions, field personnel will take regular work breaks. Extra clothing will be brought to accommodate changes in weather. Cold stress can be manifested as hypothermia (discussed further in Section 12.2.2 of the overall HASP; Anchor QEA 2009). Heat-related illnesses can occur at any time when protective clothing is worn. When air temperatures average 70 to 75°F, the risk of heat-related illnesses increases. Heat stress can be manifested as both heat stroke and heat exhaustion (discussed further in Section 12.2.1 of the overall HASP; Anchor QEA 2009).

Personnel should monitor their own conditions and capabilities and are responsible for taking appropriate measures to relieve fatigue, exposure, or heat stress. Because fatigue and extreme heat/cold stress may impair an individual's judgment, the FL/SSO is also responsible for monitoring workers' apparent condition in relation to physical exposure. The FL/SSO and vessel operator may direct any crew member to cease working if conditions indicate the potential for overexposure or if overexposure.

4.3.6 Other Physical Hazards

Incorporating the following basic safety procedures can prevent many of the most common causes of injury or accident during field sampling:

- Implement good housekeeping practices, including immediate cleanup of spills and safe storage of all materials. All equipment or materials not in current use will be removed from the immediate work area.
- Use proper lifting and moving techniques to prevent back or muscle strain or injury. Any heavy equipment, boxes, coolers, or other items should be tested before lifting. If a piece of equipment is too heavy, the equipment should be broken into smaller components or assistance requested. Lifting should be done with the legs, not the back.
- Use extra caution when handling sharp tools or sampling devices and when possible, wear protective gloves.
- Use hearing protection when working with or near a power generator, and when using a circular saw to cut sediment cores.
- Use the following safety procedures when employing extension cords:
 - Always inspect cords before using them. Use only cords in good condition to avoid electrical shocks.
 - Extension cords used in wet and/or outdoor locations have to be protected by ground fault circuit interrupters.
 - Extension cords should be a minimum of 16 American Wire Gauge size (AWG) and be rated for the equipment in use. Example: To connect an impact corer to a 2000-watt power generator, a 12 AWG (25 amps) extension cord is needed to carry the necessary current to start up the unit.

- Avoid running extension cords across walkways. Instead, run them overhead if possible and place flagging tape on the extension cord to warn of possible overhead hazard.
- An extension cord that is hot to the touch is overloaded and should be replaced.

4.4 Employee Notification of Hazards and Overall Site Information Program

The information in the JHA and the MSDSs will be made available to all employees who could be affected by it prior to the time they begin their work activities. Modifications to JHAs and the accompanying data sheets will be communicated during routine briefings.

Consistent with paragraph 1910.120 (i) of Hazardous Waste Operations and Emergency Response (HAZWOPR) (OSHA 1994), the FL/SSO will also inform other contractors and subcontractors working on this study about the nature and level of hazardous substances at the Site, the likely degree of exposure to workers who participate in Site operations, and any modifications to this Sediment Sampling HASP to other contractors and subcontractors working on this Site.

Daily safety briefings will take place before work begins. The daily briefing form provided in Exhibit 1 will be used to record the daily meetings.

Table 1
Job Hazard Analysis for Sediment Sampling – Types of Potential Hazards

Operational Phase: SJRWP RI/FS			Location: On water and impoundment area at SJRWP			
Chemical Hazards						
Chemical of Potential Concern	PEL - TWA1 mg/m ³	TLV - TWA2 mg/m ³	STEL mg/m ³	Ceiling Limit mg/m ³	Exposure Routes	Symptoms
2,3,7,8-TCDD	-	-	-	-	Inh, Abs, Ing, Con	Irritation to eyes, chloracne, dermatitis
Mercury	0.01	0.025	0	0.1	Inh, Ing, Con	Irritation to eyes, skin, cough, chest pain, dyspnea, bronchitis, pneumonitis; tremor, insomnia, irritability, indecision, headache, lassitude; stomatitis, salivation; gastrointestinal disturbance, anorexia, weight loss; proteinuria
Copper (fume)	0.1	0.2	-	-	Inh, Con	Fever, chills, muscle ache, nausea, dry throat, weakness
Physical Hazards						
Name of Physical Hazard		Source		Exposure Level/Potential		Exposure Limit
Boating operations		Boat deck		Likely		N/A
Pinch and crush zones		Boat winch and crane		Likely		N/A
Drowning		Boat/intertidal area		Likely		N/A
Heat (ambient)		Sun		Likely		N/A
Cold weather operations		Boat deck area		Likely		N/A
Heavy manual lifting/moving		Sediment cores, anchor weights		Likely		N/A
Oxidizers – storage and use		Decontamination solution		Likely		N/A
Slips/trips/falls/person overboard		Boat deck area		Likely		N/A
Inclement weather – rain, wind		Boat deck area		Likely		N/A
Sharp objects – machete		Clearing impoundment area vegetation		Likely		N/A
Sharp objects – broken glass		Boat deck/impoundment area		Likely		N/A

Table 1
Job Hazard Analysis for Sediment Sampling – Types of Potential Hazards

Corrosives - storage and use	Decontamination solution	Likely	N/A
Flammable liquids – storage and use	Decontamination solution	Likely	N/A
Material handling	Sediment	Likely	N/A
Vehicular travel	Van shuttle	Likely	N/A
Working over water	Boat deck area	Likely	N/A
Operational Phase: SJRWP RI/FS		Location: On water and impoundment area at SJRWP	
Biological Hazards			
Name of Biological Hazard	Source	Exposure Level/Potential	Exposure Limit
Ragweed	Beach area	Likely	N/A
Insect bites and stings	Boat and beach area	Likely	N/A
Operational Phase: SJRWP RI/FS		Location: On water and impoundment area at SJRWP	
Control Measures Used			
Engineering Controls: see the FSP (Appendix A of this document). In addition: 1. Anchor weights of sampling boat are such that the use of the boat’s winch should be employed. 2. Weights of coolers are such that two persons should lift the units to prevent back injuries. 3. To avoid insect bites, insect repellents may be applied. 4. Field staff must bring allergy medications if allergic to ragweed. 5. The weight of the impact corer is such that careful lifting and position handling must be observed. 6. To mitigate poisoning from a snake bite, a snake bite kit will be available on Site. 7. To avoid sinking in mud, mudders will be strapped to boots or pieces of plywood will be used.			
Level of PPE: D	PPE Equipment: Chemical-resistant steel-toed boots, PVC bib-style overalls and jacket with hood, splash-proof safety goggles, nitrile gloves, hardhat, PFD Type III.		
Location: On boat deck			
Location: Intertidal area, impoundment area	PPE Equipment: Chemical-resistant steel toe boots, PVC Bib-style overalls (and jacket with hood as necessary), splash-proof safety goggles, nitrile gloves, chest or hip waders, mudders, PFD Type III.		
Work Practices:	Change disposable nitrile gloves frequently. Wash hands and face with soap and water after each sampling event. Take shower at end of workday.		

Notes:

¹ PEL-TWA values from NIOSH Pocket Guide to Chemical Hazards (1997).² TLV-TWA values from American Conference of Governmental Industrial Hygienists (ACGIH1996).³ PEL and TLV values for coal tar pitch volatiles include anthracene, benzo(a)pyrene, chrysene, and pyrene.*Naphthalene: 50 mg/m³ = 10 ppm (NIOSH 1997).

Inh = Inhalation, Abs = Absorption, Con = Contact, Ing = Ingestion

NA = Not applicable.

NE = Not established.

5 SITE CONTROL ZONES

The definitions of the Site control zones are discussed in Section 7.3 of the overall HASP (Anchor QEA 2009). The use of Site control zones is designed to reduce the spread of hazardous substances from contaminated areas to clean areas, to identify and isolate contaminated areas of the Site, to facilitate emergency evacuation and medical care, to prevent unauthorized entry to the Site, and to deter vandalism and theft.

5.1 Sediment Sampling

5.1.1 Exclusion Zone

Exclusion zones will be established wherever exposed sediment is handled:

Sampling Vessel: During intrusive sampling on a sampling vessel, the exclusion zone includes the area of the vessel in which sediments collected from the river bottom are handled. This part of the vessel is designated as the exclusion zone only when sediment samples are being handled on the vessel.

Nearshore Intertidal Sampling: When sampling nearshore intertidal sediments, the exclusion zone will be the area within a 6-foot radius around the sampling point. The same area will apply when homogenizing sediments on Site. A designated member of the field team will be tasked with preventing unauthorized individuals from entering the exclusion zone.

Field Processing Area: Onshore facilities may be used for all sediment core processing activities, including a mobile facility that may be used for subsurface sediment sample processing. Otherwise, a canopy with plastic walls and ground plastic cover may be used as a field processing area. Each sediment processing facility or field processing area under a canopy will be identified by a clearly marked exclusion zone where all sediment handling will occur. The exclusion zone boundaries will be marked with caution tape, orange traffic safety cones, or equivalent. A designated member of the field team will be tasked with preventing unauthorized individuals from entering the field processing area.

5.1.2 Contamination Reduction Zone

Contamination reduction zones (CRZs) will be established wherever decontamination of sampling equipment and personnel exposed to sediment is conducted:

Sampling Vessel: The CRZ during on-water sediment handling is the same area on the vessel deck after intrusive sampling has occurred. Decontamination of both personnel and equipment will take place in this zone to prevent the transfer of COPCs to the support zone.

Nearshore Intertidal Sampling: When sampling nearshore intertidal sediments, field personnel may carry the sampling equipment and sampling bowls containing sediment samples back to the field processing area (if one is used). The CRZ zone will be the reserved area outside the exclusion zone of the field processing area where decontamination of both personnel and field equipment will take place and prevent the transfer of COPCs to the support zone.

Field Processing Area: A reserved area outside the exclusion zone where decontamination of both personnel and equipment will occur to prevent the transfer of COPCs to the support zone. As appropriate, the boundaries of the field processing area will be marked with caution tape, orange traffic safety cones, or equivalent.

5.2 Support Zone

The support zone will be located wherever exposed contaminated sediments are not present. In general, the support zone is where sample processing occurs after sediment samples have been sealed in sample jars and inserted into resealable plastic bags. It is also the area where chain-of-custody forms are completed, sample jar labels are prepared, and sample jars are packed for shipping.

Sampling Vessel: The support zone is the cabin area of the vessel or on the vessel deck where contaminated sediments are not present.

Nearshore Intertidal Sampling: The support zone will be located adjacent to the field processing area and may consist of a separate room in a field lab (if used), the inside space of

a cargo van or trailer, or an area under another canopy with clean tables and chairs where sediments are not being processed.

Field Processing Area: The support zone will be located adjacent to the field processing area and may consist of a separate room in a field lab (if used), the inside space of a cargo van or trailer or, an area under another canopy with clean tables and chairs where sediments are not being processed.

5.3 Project Air Monitoring Requirements

Section 11 of the overall HASP (Anchor QEA 2009) provides general requirements for air monitoring during the 2010 sediment study, including information on air monitoring equipment. Previous investigations of the Site indicate that the main chemicals of interest for worker health and safety during the sampling event(s) are dioxins and furans. There is no evidence of significant concentrations of volatile chemicals in sediment or surface water. Therefore, respiratory protection is not expected to be needed and either Level D (off-site sample handling) or Level Modified D PPE (sampling activities) will be used.

5.4 Decontamination of Sampling Equipment

Decontamination of sampling equipment will follow procedures in Section 2.2.5 of the field sampling plan for this study HASP. No chemical solvents will be required for decontamination of sampling equipment.

All vehicles, vessels, and equipment that have entered potentially contaminated areas will be visually inspected and, if necessary, decontaminated prior to leaving the area by rinsing tires and wheel wells with Alconox® detergent and water. An effort will be made to keep vehicles away from contaminated soil and sediment by parking on the service road and carrying field sampling equipment to the Site on foot or by using carts or sleds. Large tools will be cleaned in the same manner. Small reusable sampling equipment, including bowls, spoons, and knives, will be rinsed, washed in phosphate-free detergent, and rinsed again. All personnel walking over the impoundment area will have their boots decontaminated as well. Rinsate from all decontamination activities will be collected for proper disposal. Decontamination of equipment and tools will take place within the CRZ.

The following supplies will be available to perform decontamination activities:

- Wash and rinse buckets
- Tap water and phosphate-free detergent (i.e., Alconox[®] or Liquinox[®])
- Scrub brushes
- Distilled/deionized water
- Deck pump with pressurized water hose (aboard the vessel)
- Pressure washer/steam cleaner, if appropriate
- Paper towels and plastic garbage bags
- 50-gallon drums with labels and lids or 5-gallon plastic buckets with labels and lids to segregate rinsed waste water and solid waste derived from sediment sampling and processing activities.

6 REFERENCES

- ACGIH. 1996. Threshold Limit Values (TLV) for Chemical Substances and Physical Agents Biological Exposure Indices (BEIs). American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.
- Anchor QEA. 2009. Health and Safety Plan San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and U.S. Environmental Protection Agency, Region 6. Anchor QEA, LLC, Ocean Springs, MS.
- NIOSH. 1997. National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards. Keller & Associates, Neenah, Wisconsin.
- OSHA. 1994. 29 CFR Parts 1910 and 1926. Hazardous Waste Operations and Emergency Response. Department of Labor, Occupational Safety and Health Administration. Accessed web site on January 8, 2010.
http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=STANDARDS&p_toc_level=1&p_keyvalue=1910
- OSHA. 1997. EPA/Labor Superfund Health & Safety Task Force: OSHA Audits of Superfund Sites From 1993 to 1996. Department of Labor, Occupational Safety and Health Administration. August 25, 1997. Accessed web site on January 8, 2010.
<http://www.osha.gov/SLTC/hazardouswaste/sftaskrpt.html>

EXHIBIT 1

HEALTH AND SAFETY FORMS



DATE: _____

PROJECT NAME: _____

PROJECT NO: _____

DAILY SAFETY BRIEFING

PERSON CONDUCTING
MEETING: _____

HEALTH & SAFETY
OFFICER: _____

PROJECT
MANAGER: _____

TOPICS COVERED:

- | | | |
|--|---|---|
| <input type="checkbox"/> Emergency Procedures and Evacuation Route | <input type="checkbox"/> Lines of Authority | <input type="checkbox"/> Lifting Techniques |
| <input type="checkbox"/> Directions to Hospital | <input type="checkbox"/> Communication | <input type="checkbox"/> Slips, Trips, and Falls |
| <input type="checkbox"/> HASP Review and Location | <input type="checkbox"/> Site Security | <input type="checkbox"/> Hazard Exposure Routes |
| <input type="checkbox"/> Safety Equipment Location | <input type="checkbox"/> Vessel Safety Protocols | <input type="checkbox"/> Heat and Cold Stress |
| <input type="checkbox"/> Proper Safety Equipment Use | <input type="checkbox"/> Work Zones | <input type="checkbox"/> Overhead and Underfoot Hazards |
| <input type="checkbox"/> Employee Right-to-Know/MSDS Location | <input type="checkbox"/> Vehicle Safety and Driving/Road Conditions | <input type="checkbox"/> Chemical Hazards |
| <input type="checkbox"/> Fire Extinguisher Location | <input type="checkbox"/> Equipment Safety and Operation | <input type="checkbox"/> Flammable Hazards |
| <input type="checkbox"/> Eye Wash Station Location | <input type="checkbox"/> Proper Use of PPE | <input type="checkbox"/> Biological Hazards |
| <input type="checkbox"/> Buddy System | <input type="checkbox"/> Decontamination Procedures | <input type="checkbox"/> Eating/Drinking/Smoking |
| <input type="checkbox"/> Self and Coworker Monitoring | <input type="checkbox"/> Other: | |

WEATHER CONDITIONS: _____

DAILY WORK SCOPE: _____

SITE-SPECIFIC HAZARDS: _____

SAFETY COMMENTS: _____

ATTENDEES

PRINTED NAME

SIGNATURE

Integral Consulting Inc. Employee Exposure/Injury/Illness Incident Report

Employee: _____ Employee ID No. _____

Sex: M ____ F ____ Office location: _____

Incident:

Possible exposure: _____ Known exposure: _____

Physical injury/illness: _____

Check only **one** below for **illness**:

- | | |
|---|--|
| <input type="checkbox"/> Occupational skin diseases or disorders | <input type="checkbox"/> Disorders due to physical agents |
| <input type="checkbox"/> Dust diseases of the lungs | <input type="checkbox"/> Disorders associated with repetitive motion |
| <input type="checkbox"/> Respiratory conditions due to toxic agents | <input type="checkbox"/> All other occupational illnesses |

Location: _____ Contract or Overhead No. _____

Date of incident: _____ Time of incident: _____

Date incident reported: _____ Person to whom incident was reported: _____

Date of initial medical diagnosis: _____

Weather condition during incident: Temperature: _____ Humidity: _____

Wind speed and direction: _____ Cloud cover: _____

Clear: _____ Precipitation: _____

Name of materials potentially encountered:

Chemical (liquid, solid, gas, vapor, fume, mist): _____

Radiological: _____

Biological or Other: _____

Describe the exposure/injury/illness in detail, the parts of the body affected, and how the incident occurred (attach extra sheets if necessary):

Was medical treatment given? Yes ___ No ___ If so, when? _____

By whom? Name of paramedic: _____

Name of physician: _____

Other: _____

Where? Onsite ___ Offsite ___

If offsite, name of hospital or clinic: _____

Length of inpatient stay (dates): _____

Was corporate management notified? No ___ Yes ___ When? _____

Name and title of manager(s) notified: _____

Did the exposure/injury/illness result in death? No ___ Yes ___ Date: _____

Did the exposure/injury/illness result in permanent disability? No ___ Yes ___ If yes, explain:

Days away from work: _____ Days of restricted work activity: _____

Has the employee returned to work? No ___ Yes ___ If yes, date: _____

Name of other persons affected during the incident:

Names of persons who witnessed the incident:

Name and title of field team leader or immediate supervisor at the site:

Was the operation being conducted under an established safety plan? No ____ Yes ____

If yes, attach a copy. If no, explain: _____

Were protective equipment and clothing used by the employee? No ____ Yes ____ If yes, list items:

Did any limitations in safety equipment or protective clothing affect or contribute to exposure? If so, explain:

What was the employee doing when the exposure/injury/illness occurred? (Describe briefly as site reconnaissance, site categorization, sampling, etc.):

Describe exact onsite or offsite location where the incident occurred:

How did the incident occur? Describe fully the factors that led to or contributed to the incident:

Attachments to this report: ☐ Medical report(s) if not confidential ☐ Site safety plan ☐
Other relevant information ☐

Employee's signature

Date

Project Manager's signature

Date

Site safety officer's signature

Date

Corporate health and safety officer's signature

Date

Management review and comments:

Medical consultant's comments:

Physician's signature

Date

Corporate health and safety officer review and comments

Action required? No ____ Yes ____

If yes, what action?

Follow-up action carried out:

Corrective actions to be taken to prevent similar incidents:

Corporate health and safety officer's signature

Date

Employee's signature

Date

Field team leader's signature

Date

Site safety officer's signature

Date

Project manager's signatures

Date

Supervisor's signature

Date

ATTACHMENT A2

STANDARD OPERATING PROCEDURES

LIST OF STANDARD OPERATING PROCEDURES

Integral Consulting Inc.

SOP AP-01	Sample Packaging and Shipping
SOP AP-02	Field Documentation
SOP AP-03	Sample Custody
SOP AP-04	Sample Labeling
SOP AP-05	Investigation-Derived Waste Handling
SOP AP-06	Navigation and Station Positioning
SOP SD-01	Decontamination of Sediment Sampling Equipment
SOP SD-02	Preparation of Field Quality Control Samples for Sediments
SOP SD-04	Surface Sediment Sampling
SOP SD-06	Hollow-Stem Auger Drilling/Sediment Sampling
SOP SD-08	Subsurface Sediment Core Collection
SOP SD-12	Logging of Sediment Cores
SOP SD-13	Field Classification of Sediment
SOP SL-05	Surface Soil Sampling
SOP SL-06	Logging of Soil Boreholes

Anchor QEA

SOP 2.1	Sediment Grab Sampling
SOP 6.2	SPT and Split Spoon Sampling
SOP 6.3	Thin Wall Sampling
SOP 6.6	Instruction Manual, Field Inspection Vane Tester (Model H-60)

INTEGRAL CONSULTING INC.

STANDARD OPERATING PROCEDURE (SOP) AP-01

SAMPLE PACKAGING AND SHIPPING

SCOPE AND APPLICATION

This SOP describes specific requirements for sample packaging and shipping to ensure the proper transfer and documentation of environmental samples collected during field operations. Procedures for the careful and consistent transfer of samples from the field to the laboratory are outlined herein. This SOP also presents the method to be used when packing samples that will either be hand delivered or shipped by commercial carrier to the laboratory.

EQUIPMENT AND SUPPLIES REQUIRED

Make sure that you have the equipment and supplies necessary to properly pack and ship environmental samples, including the following:

- Project-specific sampling and analysis plan (SAP)
- Project-specific field logbook
- Sealable airtight bags in assorted sizes (e.g., Ziploc®)
- Wet ice in doubled, sealed bags; frozen Blue Ice®; or dry ice
- Cooler(s)
- Bubble wrap
- Fiber-reinforced packing tape, clear plastic packing tape, and duct tape
- Scissors or knife
- Chain-of-custody (COC) forms
- COC seals
- Large plastic garbage bags (preferably 3 mil [0.003 in.] thick)
- Paper towels
- "Fragile," "This End Up," or "Handle With Care" labels
- Mailing labels
- Air bills for overnight shipment

PROCEDURE

Customize the logistics for sample packaging and shipping to each study. If necessary, transfer samples from the field to a local storage facility where they can be frozen or refrigerated. Depending on the logistics of the operation, field personnel may transport samples to the laboratory or use a commercial courier or shipping service. In the latter case, Integral field personnel must be aware of any potentially limiting factors to timely shipping, such as availability of overnight service and weekend deliveries to specific areas, and shipping regulations regarding “restricted articles” (e.g., dry ice, formalin) prior to shipping the samples.

SAMPLE PREPARATION

Take the following steps to ensure the proper transfer of samples from the field to the laboratories:

At the sample collection site:

1. Document all samples using the proper logbooks or field forms (see SOP AP-02), required sample container identification (i.e., sample labels with tag numbers), and COC form (example provided in SOP AP-03). Fill out the COC form as described in SOP AP-03, and use the sample labeling techniques provided in SOP AP-04.
2. Make all applicable laboratory quality control sample designations on the COC forms. Clearly identify samples that will be archived for future possible analysis. Label these samples as follows: “Do Not Analyze: Hold and archive for possible future analysis.” Some laboratories interpret “archive” to mean that they should continue holding the residual sample after analysis.
3. Notify the laboratory contact and the Integral project quality assurance/quality control (QA/QC) coordinator that samples will be shipped and the estimated arrival time. Send copies of all COC forms to Integral’s project QA/QC coordinator or project manager, as appropriate.
4. Keep the samples in the possession of the sampling personnel at all times. Lock and secure any temporary onsite sample storage areas to maintain sample integrity and COC requirements.
5. Clean the outside of all dirty sample containers to remove any residual material that may lead to cross-contamination.
6. Complete the COC form as described in SOP AP-03, and retain the back (pink) copy for project records prior to sealing the cooler. Check sample containers against the COC form to ensure all the samples that were collected are in the cooler.

7. Store each sample container in a sealed plastic bag that allows the sample label (example provided in SOP AP-03) to be read. Before sealing the bags, ensure that volatile organic analyte (VOA) vials are encased in a foam sleeve or in bubble wrap.
8. If the samples require storage at a specific temperature, place enough ice in the sample cooler to maintain the temperature (e.g., 4°C) throughout the sampling day.

At the sample processing area (immediately after sample collection) take the following steps:

1. If the samples require a specific storage temperature, then cool the samples and maintain the temperature prior to shipping. For example, place enough ice in each sample cooler to maintain the temperature at 4°C until processing begins at the testing laboratory.
2. Be aware of holding time requirements for project-specific analytes and arrange the sample shipping schedule accordingly.
3. Place samples in secure storage (i.e., locked room or vehicle) or keep them in the possession of Integral sampling personnel before shipment. Lock and secure any sample storage areas to maintain sample integrity and COC requirements.
4. Store samples in the dark (e.g., keep coolers shut).

At the sample processing area (just prior to shipping), do the following:

1. Check sample containers against the COC form to account for all samples intended for shipment.
2. Choose cooler(s) of appropriate size and make sure they are clean of gross contamination inside and out. If the cooler has a drain, close the drain and secure it with duct tape.
3. Line the cooler with bubble wrap and place a large plastic bag (preferably with a thickness of 3 mil), open, inside the cooler.
4. Individually wrap each glass container (which was sealed in a plastic bag at the collection site) in bubble wrap and secure with tape or a rubber band. Place the wrapped samples in the large plastic bag in the cooler, leaving room for ice to keep the samples cold (i.e., 4°C).
5. If temperature blanks have been provided by the testing laboratory, place one temperature blank in each sample cooler.
6. If the samples require a specific storage temperature, add enough wet ice or Blue Ice[®] to maintain that temperature during overnight shipping (i.e., 4°C). Always overestimate the amount of ice that will be required. Keep ice in a sealed plastic bag, which is placed in a second sealed plastic bag to prevent leakage. Avoid separating the samples from the ice with excess bubble wrap because it may insulate the samples from the ice. After adding all samples and ice to the cooler, use bubble wrap (or other

available clean packing material) to fill any empty space and prevent the samples from shifting during transport.

7. If possible, consolidate all VOA samples in a single cooler and ship them with (a) trip blank(s) if the project-specific QA project plan calls for them.
8. Sign, date, and include any tracking numbers provided by the shipper on the COC form. Remove the back (pink) copy of the original COC form and retain this copy for the project records.
9. Seal the rest of the signed COC form in a bag and tape the bag to the inside of the cooler lid. Each cooler should contain an individual COC form for the samples contained inside it. If time is short and it becomes necessary to combine all the samples onto a single set of COC forms and ship multiple coolers together, then indicate on the outside of the appropriate cooler, "Chain-of-Custody Inside."
10. After the cooler is sufficiently packed to prevent shifting of the containers, close the lid and seal it with fiber-reinforced packing tape. Tape the cooler around the opening, joining the lid to the bottom, and around the circumference of the cooler at both hinges.
11. As security against unauthorized handling of the samples, apply two COC seals across the opening of the cooler lid (provided with example field forms). Place one seal on the front right portion of the cooler and one on the back left. Be sure the seals are properly affixed to the cooler to prevent removal during shipment. Additional tape across the seal may be necessary if the outside of the cooler is wet.

SAMPLE SHIPPING

Hand Delivery to the Testing Laboratory

1. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be delivered to the laboratory and the estimated arrival time.
2. When hand-delivering environmental samples, make sure the testing laboratory receives them on the same day that they were packed in the coolers.
3. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after it has been faxed. Never leave the original COC form in the custody of non-Integral staff.

Shipped by Commercial Carrier to the Laboratory

1. Apply a mailing label to the cooler with destination and return addresses, and add other appropriate stickers, such as "This End Up," "Fragile," and "Handle With Care." If the shipment contains multiple coolers, indicate on the mailing label the number of coolers that the testing laboratory should expect to receive (e.g., 1 of 2; 2 of 2). Place clear tape over the mailing label to firmly affix it to the cooler and to protect it from the weather. This is a secondary label in case the air bill is lost during shipment.
2. Fill out the air bill and fasten it to the handle tags provided by the shipper (or the top of the cooler if handle tags are not available).
3. If samples must be frozen (-20°C) during shipping, make sure that dry ice has been placed in the sample cooler. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require.
4. Make sure that benthic infauna samples have been preserved with formalin in the field prior to shipping. Be aware of any additional shipping, handling, and special labeling requirements that the shipper may require for these samples.
5. Notify the laboratory contact and the Integral project QA/QC coordinator that samples will be shipped and the estimated arrival date and time. If environmental samples must be shipped at 4°C or -20°C , choose overnight shipping for delivery next morning. Fax or scan and e-mail copies of all COC forms to the Integral project QA/QC coordinator. Note: It may be necessary to photocopy the COC form on a slightly darker setting so the form is readable after faxing. Never leave the original COC form in the custody of non-Integral staff.

STANDARD OPERATING PROCEDURE (SOP) AP-02

FIELD DOCUMENTATION

SCOPE AND APPLICATION

This SOP describes the Integral procedure for accurate record-keeping in the field for the purposes of ensuring that samples can be traced from collection to final disposition.

Document all information relevant to field operations properly to ensure that activities are accounted for in written records to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. Several types of field documents are used for this purpose and should be consistently used by field personnel. Field documentation should include only a factual description of site-related activities and observations. Field personnel should not include superfluous comments or speculation regarding the field activities or observations.

FIELD LOGBOOKS

During field sampling events, field logbooks must be used to record all daily activities. The purpose of the field logbook is to document events and record data measured in the field to the extent that someone not present at the site could reconstruct the activity without relying on the memory of the field crew. The project manager (or designee) should issue a field logbook to the appropriate site personnel for the direction of onsite activities (e.g., reconnaissance survey team leader, sampling team leader). It is this designee's responsibility to maintain the site logbook while it is in his or her possession and return it to the project manager or turn it over to another field team.

Make entries in the field logbook as follows:

1. Document all daily field activities in indelible ink in the logbook and make no erasures. Make corrections with a single line-out deletion, followed by the author's initials and the date. The author must initial and date each page of the field logbook. The author must sign and date the last page at the end of each day, and draw a line through any blank space remaining on the page below the last entry.

2. Write the project name, dates of the field work, site name and location (city and state), and Integral job number on the cover of the field logbook. If more than one logbook is used during a single sampling event, then annotate the upper right-hand corner of the logbook (e.g., Volume 1 of 2, 2 of 2) to indicate the number of logbooks used during the field event. Secure all field logbooks when not in use in the field. The following is a list of the types of information that is appropriate for entry in the field notebook:
 - Project start date and end date
 - Date and time of entry (24-hour clock)
 - Time and duration of daily sampling activities
 - Weather conditions at the beginning of the field work and any changes that occur throughout the day, including the approximate time of the change (e.g., wind speed and direction, rain, thunder, wave action, current, tide, vessel traffic, air and water temperature, thickness of ice if present)
 - Name and affiliation of person making entries and other field personnel and their duties, including what times they are present
 - The location and description of the work area, including sketches, map references, and photograph log, if appropriate
 - Level of personal protection being used
 - Onsite visitors (names and affiliations), if any, including what times they are present
 - The name, agency, and telephone number of any field contacts
 - Notation of the coordinate system used to determine the station location
 - The sample identifier and analysis code for each sample to be submitted for laboratory analysis, if not included on separate field data sheets
 - All field measurements made (or reference to specific field data sheets used for this purpose), including the time of collection and the date of calibration, if appropriate
 - The sampling location name, date, gear, water depth (if applicable), and sampling location coordinates, if not included on separate field data sheets
 - For aquatic sampling, the type of vessel used (e.g., size, power, type of engine)
 - Specific information on each type of sampling activity
 - The sample type (e.g., groundwater, soil, surface sediment), sample number, sample tag number, and any preservatives used, if not included on separate field data sheets
 - Sample storage methods

- Cross-references of numbers for duplicate samples
 - A description of the sample (source and appearance, such as soil or sediment type, color, texture, consistency, presence of biota or debris, presence of oily sheen, changes in sample characteristics with depth, presence/location/thickness of the redox potential discontinuity [RPD] layer, and odor) and penetration depth, if not included on separate field data sheets
 - Estimate of length and appearance of recovered cores, if not included on separate field data sheets
 - Photographs (uniquely identified) taken at the sampling location, if any
 - Details of the work performed
 - Variations, if any, from the project-specific sampling and analysis plan (SAP) or standard operating protocols and reasons for deviation
 - Details pertaining to unusual events that might have occurred during sample collection (e.g., possible sources of sample contamination, equipment failure, unusual appearance of sample integrity, control of vertical descent of the sampling equipment)
 - References to other logbooks or field forms used to record information (e.g., field data sheets, health and safety log)
 - Any field results not appearing on the field data sheets (if used), including station identification and location, date, and time of measurement
 - Sample shipment information (e.g., shipping manifests, chain-of-custody (COC) form numbers, carrier, air bill numbers, time addresses)
 - A record of quantity of investigation-derived wastes (if any) and storage and handling procedures.
3. During the field day, as listed above, record in the logbook a summary of all site activities. Provide a date and time for each entry. The information need not duplicate anything recorded in other field logbooks or field forms (e.g., site health and safety officer's logbook, calibration logbook, field data sheets), but should summarize the contents of the other logbooks and refer to the pages in these logbooks for detailed information.
4. If measurements are made at any location, record the measurements and equipment used, or refer to the logbook and page number(s) or field forms on which they are recorded. All maintenance and calibration records for equipment should be traceable through field records to the person using the instrument and to the specific piece of instrumentation itself.

5. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field logbooks to be copied. A discussion of copy distribution is provided below.

FIELD DATA FORMS

Occasionally, additional field data forms are generated during a field sampling event (e.g., groundwater monitoring form, sediment core profile form, water quality measurement form) to record the relevant sample information collected. For instructions regarding the proper identification of field data forms, sampling personnel should consult the project-specific SAP.

Upon completion of the field sampling event, the sampling team leader will be responsible for submitting all field data forms to be copied. A discussion of copy distribution is provided below.

PHOTOGRAPHS

In certain cases, photographs (print or digital) of sampling stations may be taken using a camera-lens system with a perspective similar to the naked eye. Ensure that photographs include a measured scale in the image, when practical. If you take photographs of sample characteristics and routine sampling activities, avoid using telephoto or wide-angle shots, because they cannot be used in enforcement proceedings. Record the following items in the field logbook for each photograph taken:

1. The photographer's name or initials, the date, the time of the photograph, and the general direction faced (orientation)
2. A brief description of the subject and the field work shown in the picture
3. For print photographs, the sequential number of the photograph and the roll number on which it is contained
4. For digital photographs, the sequential number of the photograph, the file name, the file location, and back-up disk number (if applicable).

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all photographic materials to be developed (prints) or copied (disks). Place the prints or disks and associated negatives in the project files (at the Integral project manager's location). Make photocopies of photo logs and any supporting documentation from the field logbooks, and place them in the project files with the prints or disks.

EQUIPMENT CALIBRATION RECORDS

Record in the field logbook all equipment calibration records, including instrument type and serial number, calibration supplies used, calibration methods and calibration results, date, time, and personnel performing the calibration. Calibrate all equipment used during the investigation daily, at a minimum, in accordance with the manufacturers' recommendations.

DISTRIBUTION OF COPIES

At Integral offices, make two copies of all field logbooks and additional field data forms. Stamp the first copy with a "COPY" stamp, and place it in the project file to be available for general staff use. Stamp the second copy with a "FILE" stamp, and place it in the data management file with the laboratory data packages, to be used by the data management and quality assurance staff only. Place the original field logbooks and forms in a locked file cabinet.

SET-UP OF LOCKING FILE CABINET

Place each project in its own file folder in a locking file cabinet. On the folder label, include the project name and contract number. Each project folder will include up to six kinds of files:

- Field logbook(s)
- Additional field data forms
- Photographs
- COC forms
- Acknowledgment of Sample Receipt forms
- Archive Record form (to be completed only if samples are archived at an Integral field storage facility or Integral laboratory).

STANDARD OPERATING PROCEDURE (SOP) AP-03

SAMPLE CUSTODY

SCOPE AND APPLICATION

This SOP describes Integral procedures for custody management of environmental samples.

A stringent, established program of sample chain-of-custody will be followed during sample storage and shipping activities to account for each sample. The procedure outlined herein will be used with SOP AP-01, which covers sample packaging and shipping; SOP AP-02, which covers the use of field logbooks and other types of field documentation; and SOP AP-04, which covers sample labeling. Chain-of-custody (COC) forms ensure that samples are traceable from the time of collection through processing and analysis until final disposition. A sample is considered to be in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession
2. The sample is in the person's view after being in his or her possession
3. The sample is in the person's possession and is being transferred to a designated secure area
4. The sample has been locked up to prevent tampering after it was in the person's possession.

At no time is it acceptable for samples to be outside of Integral personnel's custody unless the samples have been transferred to a secure area (i.e., locked up). If the samples cannot be placed in a secure area, then an Integral field team member must physically remain with the samples (e.g., at lunch time one team member must remain with the samples).

CHAIN-OF-CUSTODY FORMS

The COC form is critical because it documents sample possession from the time of collection through final disposition. The form also provides information to the laboratory regarding what analyses are to be performed on the samples that are shipped.

Complete the COC form after each field collection activity and before shipping the samples to the laboratory. Sampling personnel are responsible for the care and custody of the samples until they are shipped. The individuals relinquishing and receiving the samples must sign the

COC form(s), indicating the time and date of the transfer, when transferring possession of the samples.

A COC form consists of three-part carbonless paper with white, yellow, and pink copies. The sampling team leader keeps the pink copy. The white and yellow sheets are placed in a sealed plastic bag and secured inside the top of each transfer container (e.g., cooler). Field staff retain the pink sheet for filing at the Integral project manager's location. Each COC form has a unique four-digit number. This number and the samples on the form must be recorded in the field logbook. Integral also uses computer-generated COC forms. If computer-generated forms are used, then the forms must be printed in triplicate and all three sheets signed so that two sheets can accompany the shipment to the laboratory and one sheet can be retained on file. Alternatively, if sufficient time is available, the computer-generated forms will be printed on three-part carbonless paper.

Record on the COC form the project-assigned sample number and the unique tag number at the bottom of each sample label. The COC form also identifies the sample collection date and time, type of sample, project name, and sampling personnel. In addition, the COC form provides information on the preservative or other sample pretreatment applied in the field and the analyses to be conducted by referencing a list of specific analyses or the statement of work for the laboratory. The COC form is sent to the laboratory along with the sample(s).

PROCEDURES

Use the following guidelines to ensure the integrity of the samples:

1. Sign and date each COC form. Have the person who relinquishes custody of the samples also sign this form.
2. At the end of each sampling day and prior to shipping or storage, make COC entries for all samples. Check the information on the labels and tags against field logbook entries.
3. Do not sign the COC form until the team leader has checked the information for inaccuracies. Make corrections by drawing a single line through any incorrect entry, and then initial and date it. Make revised entries in the space below the entries. After making corrections, mark out any blank lines remaining on the COC form, using single lines that are initialed and dated. This procedure will prevent any unauthorized additions.

At the bottom of each COC form is a space for the signatures of the persons relinquishing and receiving the samples and the time and date of the transfer. The time the samples were relinquished should match exactly the time they were received by another party. Under no circumstances should there be any time when custody of the samples is undocumented.

4. If samples are sent by a commercial carrier not affiliated with the laboratory, such as FedEx or United Parcel Service (UPS), record the name of the carrier on the COC form. Also enter on the COC form any tracking numbers supplied by the carrier. The time of transfer should be as close to the actual drop-off time as possible. After signing the COC forms and removing the pink copy, seal them inside the transfer container.
5. If errors are found after the shipment has left the custody of sampling personnel, make a corrected version of the forms and send it to all relevant parties. Fix minor errors by making the change on a copy of the original with a brief explanation and signature. Errors in the signature block may require a letter of explanation.
6. Provide a COC form and an Archive Record form for any samples that are archived internally at Integral.

Upon completion of the field sampling event, the sampling team leader is responsible for submitting all COC forms to be copied. A discussion of copy distribution is provided in SOP AP-02.

CUSTODY SEAL

As security against unauthorized handling of the samples during shipping, affix two custody seals to each sample cooler. Place the custody seals across the opening of the cooler (front right and back left) prior to shipping. Be sure the seals are properly affixed to the cooler so they cannot be removed during shipping. Additional tape across the seal may be prudent.

SHIPPING AIR BILLS

When samples are shipped from the field to the testing laboratory via a commercial carrier (e.g., FedEx, UPS), the shipper provides an air bill or receipt. Upon completion of the field sampling event, the sampling team leader will be responsible for submitting the sender's copy of all shipping air bills to be copied at an Integral office. A discussion of copy distribution is provided in SOP AP-02. Note the air bill number (or tracking number) on the applicable COC forms or, alternatively, note the applicable COC form number on the air bill to enable the tracking of samples if a cooler becomes lost.

ACKNOWLEDGMENT OF SAMPLE RECEIPT FORMS

In most cases, when samples are sent to a testing laboratory, an Acknowledgment of Sample Receipt form is faxed to the project QA/QC coordinator the day the samples are received by the laboratory. The person receiving this form is responsible for reviewing it, making sure that the laboratory has received all the samples that were sent, and verifying that the correct analyses were requested. If an error is found, call the laboratory immediately, and document

any decisions made during the telephone conversation, in writing, on the Acknowledgment of Sample Receipt form. In addition, correct the COC form and fax the corrected version to the laboratory.

Submit the Acknowledgment of Sample Receipt form (and any modified COC forms) to be copied. A discussion of copy distribution is provided in SOP AP-02.

ARCHIVE RECORD FORMS

On the rare occasion that samples are archived at an Integral office, it is the responsibility of the project manager to complete an Archive Record form. This form is to be accompanied by a copy of the COC form for the samples, and will be placed in a locked file cabinet. The original COC form remains with the samples in a sealed Ziploc® bag.

STANDARD OPERATING PROCEDURE (SOP) AP-04

SAMPLE LABELING

SCOPE AND APPLICATION

This SOP describes the general Integral procedures for labeling samples, and the three kinds of labels that can be used on a project (i.e., sample labels, sample tags, and internal sample labels). Consult the project-specific sampling and analysis plan (SAP) to determine the exact sample identifiers and sample labels that are required for a given project. If they are not specified in the SAP, then follow the designations below.

SAMPLE IDENTIFIERS

Before field sampling begins, establish sample identifiers to be assigned to each sample as it is collected. Sample identifiers consist of codes designed to fulfill three purposes: 1) to identify related samples (i.e., replicates) to ensure proper data analysis and interpretation, 2) to obscure the relationships between samples so that laboratory analysis will be unbiased by presumptive similarities between samples, and 3) to track individual sample containers to ensure that the laboratory receives all material associated with a single sample. To accomplish these purposes, each container may have three different codes associated with it: the sample identifier, the sample number, and the sample tag number. These codes and their use are described as follows:

- **Sample Identification Code**—The sample identification code (Sample ID) is a unique designation that identifies where and how the sample was collected. The sample identifier is recorded in the field logbook *only* and is not provided on the sample label or chain-of-custody (COC) form. The sample identifier is a multiple-part code. The first component begins with the letter abbreviation; for example, “SWNS” or “SWNB” to designate the surface water sample was collected from the near-surface or near-bottom of the water column. The second part could identify the sampling event; for example, “1” to designate Round 1 sampling. The third part could contain an abbreviation for whether the station is a single point (SP), a transect (TR), a composite (CO), or a vertically integrated station (VI). The station number would be the final component of the sample identifier. Use leading zeros for stations with numbers below 100 for ease of data management and correct data sorting.

If appropriate, add a supplemental component to the sample identifier to code field

duplicate samples and splits. Use a single letter (i.e., a suffix of “A” and “B”) to indicate field duplicates or splits in the final component of the sample identifiers. For equipment decontamination blanks, assign sequential numbers starting at 900 instead of station numbers. Use a sample type code that corresponds to the sample type for which the decontamination blank was collected. Additional codes may be adopted, if necessary, to reflect sampling equipment requirements (see project-specific SAP).

Examples of sample IDs are as follows:

- SWNS-1-SP-002: Surface water sample collected from the near-surface at a single point during Round 1 from Station 2.
- SWNB-1-TR-010-A: Duplicate surface water sample from the near-bottom transect during Round 1 from Station 10.
- **Sample Number**—The sample number is an arbitrary number assigned to each distinct sample or split that is shipped to the laboratory for separate analysis. The sample number appears on the sample containers and the COC forms. Each sample will be assigned a unique sample number. All aliquots of a composited field sample will have the same sample number. In cases where samples consist of multiple bottles from the same location, assign each bottle the same sample number and time. However, assign replicates from the same location different sample numbers and times. Sample numbers of related field replicates will not necessarily have any shared content.

Each field split of a single sample will also have a different sample number and time. The sample number is generally a unique six-digit number that includes a two-digit media code and a four-digit number. The media code may be site-specific, but the Integral default codes are as follows:

- SS—Surface soil
- BH—Subsurface soil or rock (typically from borehole)
- GW—Groundwater
- SW—Surface water
- PW—Pore water
- SD—Sediment
- BT—Biota or biological tissue

The exact sample numbering scheme may vary from project to project. Variances in the sample numbering scheme will be described in the project-specific SAP for the field event. Example sample numbers are PW0001, PW0002, PW0003, etc.

- **Tag Number**—Attach a different tag number to each sample container. If the amount of material (i.e., everything associated with a single sample number) is too large for a single container, assign each container the same sample number and a different sample tag. A sample will also be split between containers if a different preservation technique is used for each container (i.e., because different analyses will be conducted).

The sample tag number is a unique five- or six-digit number assigned to each sample label (or “tag”) for multiple bottles per sample. Integral sample labels come with a preprinted sample tag number. The tag number provides a unique tracking number to a specific sample bottle. This allows for greater flexibility in tracking sample bottles and assists in field quality control when filling out documentation and shipping. Sample tags are not used by many other consultants, and there may be resistance from such firms during teaming situations. However, experience has shown that tags can be very valuable, both in the field and while processing data from field efforts.

Record tag numbers on the COC form. Laboratories use tag numbers only to confirm that they have received all of the containers that were filled and shipped. Data are reported by sample number.

Assign sample numbers sequentially in the field; sample labels are preprinted with sequential tag numbers.

SAMPLE LABELS

Integral sample labels are designed to uniquely identify each individual sample container that is collected during a sampling event. Field sampling teams are provided with preprinted sample labels, which must be affixed to each sample container used. Fill out the labels at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservatives used, if any
- A unique number (commonly referred to as the “Tag Number”) that is preprinted on the label consisting of five or six digits; used to identify individual containers.

SAMPLE TAGS

Integral sample tags are designed to be affixed to each container that is used for a sample. Sample tags are required only for environmental samples collected in certain U.S.

Environmental Protection Agency (EPA) regions (e.g., EPA Region 5). Field crews are provided with preprinted sample tags. Attach sample tags to each individual sample container with a rubber band or wire through a reinforced hole in the tag. Mark all sample tag entries with indelible ink. Fill out the tags at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservatives used, if any
- Type of analysis.

A space for the laboratory sample number (provided by the laboratory at log-in) will also be provided on the sample tag.

INTERNAL SAMPLE LABELS

For benthic infaunal samples, wash away the sediment from the sample and collect the remaining benthic infauna into a sample container. Affix sample label (as discussed above) to the outside of the sample container. In addition, place an internal sample label inside the sample container. This internal sample label is made of waterproof paper; be sure to make all internal sample label entries with pencil. Fill out the internal sample labels at the time the samples are collected, documenting the following information:

- Sample number
- Site name or project number
- Date and time sample is collected
- Initials of the samplers
- Preservative used (e.g., formalin).

STANDARD OPERATING PROCEDURE (SOP) AP-05

INVESTIGATION-DERIVED WASTE HANDLING

SCOPE AND APPLICATION

This SOP presents the method to be used for handling wastes generated during field sampling activities that could be hazardous. These wastes are referred to as investigation-derived waste and are subject to specific regulations.

All disposable materials used for sample collection and processing, such as paper towels and gloves, are not considered investigation-derived wastes and will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal at a solid waste landfill.

EQUIPMENT AND REAGENTS REQUIRED

- 55-gallon drums (or appropriately sized waste container)
- Paint markers
- Tools (to open and close drum)
- Ziploc® bags
- Drum labels.

PROCEDURES

1. Place solid wastes that need to be containerized in properly labeled, DOT- approved, 55-gallon drums.
2. Properly close, seal, label, and stage all filled or partially filled drums before demobilization. Properly profile full drums and have them shipped off site to a RCRA Subtitle C facility.

3. Sampling activities generate personal protective equipment and miscellaneous debris that require disposal. Remove gross contamination from these items, and place the items in plastic bags. It is acceptable to store these items in plastic bags as an interim measure. At the end of each day, dispose of the bags at an appropriate solid waste facility dumpster.

STANDARD OPERATING PROCEDURE (SOP) AP-06

NAVIGATION AND STATION POSITIONING

SCOPE AND APPLICATION

This SOP describes procedures for accurate station positioning required to ensure quality and consistency in collecting samples and in data interpretation and analysis. Station positioning must be both absolutely accurate in that it correctly defines a position by latitude and longitude, and relatively accurate in that the position must be repeatable, allowing field crew to reoccupy a station location in the future (e.g., for long-term monitoring programs).

This SOP describes the most commonly used station positioning method, differential global positioning system (DGPS). Integral uses a Trimble Pathfinder™ Pro XRS DGPS for station positioning for many field efforts. The Pro XRS offers the submeter accuracy often required for documenting sampling station locations and for re-locating previously sampled stations. A comprehensive discussion of the Trimble Pathfinder™ Pro XRS DGPS is provided in Attachments 1, 2, and 3 of this SOP.

SUMMARY OF METHOD

Global positioning system (GPS) navigation is used to position the sampler at the desired location. GPS is a satellite-based system that receives positioning data at 1-second intervals from multiple satellites at known positions in space. Standard GPS is calculated to an accuracy of about 10 m.

One can obtain a higher accuracy of approximately 2 m by applying differential corrections to the standard GPS positioning data using DGPS. These differential corrections are applied by sending GPS differential corrections to the GPS receiver via radio transmission. If the sampling location is near the coastal U.S., the U.S. Coast Guard generates differential corrections that are transmitted via radio link to the GPS receiver. If a Coast Guard station is out of range of the sampling area, then a receiver may be set up at a known (i.e., surveyed) reference point on land, or real-time satellite differential signals can be purchased from a private company (e.g., OmniSTAR).

With the Pro XRS, GPS data can be gathered to submeter accuracy using a choice of differential correction sources (i.e., free beacon differential signals such as Coast Guard beacons or OmniSTAR) without establishing a reference station. Data must be corrected to gain submeter accuracy. Free beacon or base station signals allow differential corrections to be

performed after data collection by using a nearby beacon or base station logging data files. (Note: The station must be within 300 miles of the data collection location.) For satellite-based signals, a built-in virtual base station allows for real-time data correction, eliminating the need for post-processing data in some cases. However, postprocessing data corrections can obtain accuracies in the range of 30–50 cm. These accuracies are for the horizontal (northing and easting) component only. The vertical component (elevation) accuracy ranges from submeter to 3 times larger than the horizontal accuracy.

The GPS receiver displays and transmits differentially corrected positioning data to the computer using an integrated navigation software package (e.g., HYPACK, Terrasync). The computer data are typically displayed and recorded in World Geodetic System of 1984 (WGS-1984) geographic coordinates (latitude/longitude). However, the integrated navigation system can display and record information in other datums (e.g., UTM, NAD83). The integrated navigation system, acting as a data manager, displays the sampler's position relative to a target station location in plan view on a video screen. The resulting pictorial screen presentation, as well as numeric navigation data (e.g., range and bearing to the target sampling location) assists the vessel operator (when sampling on-water) in approaching and maintaining the station position while sampling.

SUPPLIES AND EQUIPMENT

- Cable
- GPS antenna
- Telemetry antenna (for differential corrections)
- GPS receiver
- Differential corrections receiver
- Computer and monitor
- Navigation software (e.g., Terrasync)
- Logbook or log sheets.

PROCEDURES

Obtain latitude and longitude coordinates at the locations where samples are collected. An average positioning objective is to accurately determine and record the positions of all sampling locations to within 2 m. Positioning accuracies on the order of 1–3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the same level of signal. The GPS provides the operator with a listing of the time intervals during the

day when accuracies are decreased. Avoiding these times allows for better positioning accuracy.

On-Land Sampling Event

A backpack DGPS unit may be used to direct the sampling team to the proposed sampling location. To expedite field activities, enter the target station coordinates into the navigation system database prior to beginning sampling. Place the DGPS antenna as close as possible to where the sampling will occur. Once the sample(s) have been collected at the appropriate location, record the horizontal coordinates of the station in the field logbook.

On-Water Sampling Event

Mount the GPS antenna vertically at the outboard end of the vessel's boom, with the GPS antenna cable extended along the boom into the cabin. Mount the telemetry antenna for receiving differential corrections on a convenient fixture outside the cabin. Locate the GPS receiver, the differential corrections receiver, and the computer in the cabin. Orient the video screen for the computer to allow the vessel operator to observe on-screen positioning data from the helm.

Alternatively, use a backpack DGPS unit to position the sampling vessel (e.g., barge) over a proposed sampling location. Place the DGPS beacon as close as possible to where the drilling will occur (i.e., moon pool). Using the DGPS unit, direct the sampling vessel operator to the sample station location.

Once the sampling vessel is anchored at the appropriate location, record the horizontal coordinates of the station in the field logbook. To expedite field activities, enter the target station coordinates in the navigation system database prior to beginning sampling.

Positioning System Verification

GPS requires no calibration, as all signal propagation is controlled by the U.S. government (the Department of Defense for satellite signals and the U.S. Coast Guard for differential corrections). Verifying the accuracy of the GPS requires coordinates to be known for one (or more) horizontal control point within the study area. The GPS position reading at any given station can then be compared to the known control point. Verify the GPS accuracy at the beginning and end of each sampling day.

Station Positioning Activities

Use a consistent routine for each day's positioning activities. After confirming successful reception of differential signals, turn on the computer on, and boot the software. Verify the accuracy of the system at a horizontal control point, as described in the previous section.

The sampling team proceeds to a target station location selected by the team leader. That station location is then selected from a number of preselected station locations that have been entered into the integrated navigation system database. Once the station has been selected, the positioning data are displayed on the computer screen or hand-held unit to assist in proceeding to the station and in maintaining the station position during sampling. A confirmed position is recorded electronically each time a sample collection is attempted. (This means that during sediment grab sampling and coring, the locations of both accepted and rejected grabs or cores are recorded.) Upon recovery of the sampling device, read the station position northing (y) and easting (x) coordinates from the archived computer file and record them in the field logbook or on log sheets as a backup to the computer record. Also record time and water depth, if applicable. Ancillary information recorded in the field logbook may include personnel operating the GPS, tidal phase, type of sampling activity, and time when coordinates were collected.

REFERENCES

- Trimble Navigation Limited. 2001. TSC1 Asset Surveyor operation manual. Version 5.20.
<http://trl.trimble.com/dscgi/ds.py/Get/File-8145/Oper.pdf>.
- Trimble Navigation Limited. 2007. GPS tutorial. Accessed on January 12, 2007.
<http://www.trimble.com/gps/index.shtml>.

ATTACHMENT 1

PRO XRS DESCRIPTION

The Pro XRS combines a high-performance GPS receiver and antenna, beacon differential receiver, and satellite differential receiver in one compact unit. It also includes Trimble's advanced Everest™ technology, which allows users to collect accurate position data near walls, water, vehicles, or other surfaces that reflect satellite signals. Reflected signals, also called multipath signals, make it difficult for GPS receivers to accurately determine position. Everest™ uses a patented technique to remove multipath signals before measurements are used to calculate position.

Equipment Required

The GPS Pathfinder™ Pro XRS consists of the following:

- GPS receiver in backpack casing (with system batteries and cables)
- Hand-held data logger (TSC1) and cable, *or* laptop computer with Terrasync software installed and cable. (Note: Terrasync procedures are described under separate cover.)
- Pro XRS antenna, range poles, and cable
- Compass and tape measure
- Spare 12-volt camcorder and 9-volt batteries (minimum of two each) (use only Kodak, Duracell, or Energizer 9-volt batteries)
- Battery charger and power cord.

Pro XRS Setup

Follow these procedures for the proper setup of the Pro XRS:

1. Ensure that connections between batteries, receiver, and data logger are correct and secure. The coaxial antenna cable connects from the GPS receiver port "ANT" to the base of the antenna. The TSC1 cable (a "pig-tail"-type cable) connects from the bottom or top of the TSC1 to the receiver port "B," where a 9-pin serial port dongle is attached. The dual Y-clip cables should be connected from the receiver to the batteries. Alternatively, if AC power is available (e.g., aboard a vessel), then the power cable for the battery charger can be attached directly to the receiver on some models.
2. Screw the three long antenna poles together (the shorter pole may be added if necessary for taller users). Screw on the antenna and connect its cable.
3. Put backpack and/or shoulder strap on. The pouch for the data logger should be in place around the waist strap or in the backpack.

4. Screw antenna to the attachments on the top of the backpack. Wind cord around pole, and ensure the antenna is secure. Please be aware of overhead hazards, especially if working near low-hanging power lines. Severe injury or death can result.

Basic Operation of the Pro XRS

Recording a Feature

Before beginning field use, ensure that all GPS configurations and settings are set correctly for the particular use of the Pro XRS and that an appropriate data dictionary is loaded onto the TSC1 (see Attachments 2 and 3 for typical settings). These steps outline the basic use of the GPS to document a sample position or any other defined “feature.” Note that the TSC1 has both hard and soft keys that allow for its operation. The hard keys comprise all of the keys (e.g., letters and numbers) on its surface. The soft keys are the F1 through F5 hard keys. The function of these changes depending upon the context. These keys will be referred to with brackets around them (<soft-key>).

1. Turn data logger on outside in an open area. Wait for antenna to receive satellite signals. The display will read Recording Almanac, Too Few SVs, and PDOP Too High. Continue to wait until enough satellites (four) are acquired and the PDOP is below 5.0.
2. Ensure that the real-time settings are correct according to the parameters listed in Attachment 2.
3. Select **Data Collection**, and create a new rover file or open an existing file. This file should be named according to the format specified by the project GIS analyst. Note: If opening an existing file, press <NEW> to access the *Antenna Options* menu and *Start Feature* menu.
4. Enter the height of the antenna from the ground to the *Measurement Method* reference point shown in the *Antenna Options* menu and then press **ENTER** to bring up the *Start Feature* menu.
5. Pick the appropriate data dictionary to use with the rover file. Only one dictionary can be used with a rover file. Consult with the project GIS analyst to formulate the most appropriate data dictionary for the type of sampling you wish to perform. The data dictionary titled *Generic* contains only a comment field and is appropriate for simple navigation tasks. If using a data dictionary, make sure to become familiar with its attributes before recording information in the field.

6. Move to the location of the first feature for which you want to record the GPS position. Select the appropriate feature and press **ENTER** to begin logging. Log data points in accordance with the feature type. Point features should have at least 10 points collected at a stationary location. Line features should be collected while moving. If movement is stopped, press the **<PAUSE>** key. When movement starts again, press the **<RESUME>** key. Area features should be collected with enough points to define the outline of the area (e.g., a square building would have four single points, collected on each corner, and the **<PAUSE>** key would be used between each of the points).
7. Depending on the setup of the data dictionary, each feature may have one or more feature attributes. An attribute is used to record additional data associated with the feature. For example, the attributes assigned to a sediment sampling station could be the sample number, station ID, sampling gear, sediment color, odor, etc.
8. Use the **<PAUSE>** key while recording feature attributes to avoid too many data points being collected at one point feature. (Body movements while logging attributes for an extended time can decrease the accuracy of collection.) The **<PAUSE>** key must be used when recording attributes of a line or area feature because only one data point should be collected in a single location.
9. Once all attributes are entered and the feature data points are logged, press **ENTER** to complete and save the feature and move on to a new feature. Pressing **ESC** instead of **ENTER** will allow the user to abandon the logged feature without saving.
10. When all features in a given area have been recorded, from the *Data Collection* menu, press **ESC** to exit data capture and then press **<YES>** to close the file. Features are appended and saved to the file after each collection, so there is no need to “save” the file. When the Pro XRS is not in use, it should be turned off. If you need to come back to the same rover file later in the day, the rover file may be reopened at that time. Rover files may not be edited after 7 days from the first feature was created. Please consult the project GIS analyst for the best way to handle multi-week sampling projects.
11. At the end of each day, download the rover file to a PC using Pathfinder Office software.

Feature Collection Options

Offsets—The Pro XRS can collect a point or line feature while standing at a set distance away from the feature. This option may be necessary because of obstructions such as tree cover, buildings, or car traffic. For a point feature, measure the distance between the object you want recorded and the Pro XRS antenna. Use the compass to determine the bearing (e.g., west is 270°). The bearing is the direction the point should be moved for it to be located in the correct place (e.g., if you are due north of the feature, the bearing is south, or 180°; i.e., the position you want recorded is south of where you are standing). Estimate the inclination from the

feature to the GPS antenna (if altitude determination is critical, a clinometer should be used). The inclination is the degree angle up from the feature to the antenna (e.g., if the feature is 5° below the antenna position, enter -5°). During data capture, from within the feature, press the <OFFSET> button, and enter the distance, bearing, and inclination. Press **OK** to complete the feature. Note: This procedure describes an offset of a single feature. A constant offset may be applied to all features collected as well.

Nesting—While recording a line feature or an area feature, a point feature may be collected to avoid backtracking. While recording the line or area feature, press <PAUSE> and then <NEST>. The Pro XRS will prompt for collection of a new feature. Move to the feature, and collect data as for any other point feature. When the feature is complete, press **OK**. The Pro XRS is ready to resume collecting data as part of the line/area feature: press <RESUME>. (Remember to continue moving before pressing resume to avoid having multiple positions recorded in the same place in the line or area feature.)

Segmenting—While moving along a line feature, changing the attributes of that line may be necessary (e.g., because of a change in surface type from paved to dirt road). This change may be done without having to begin a new feature by pressing <PAUSE> and then <SEGMENT>. Change the appropriate attributes and then press <RESUME> to continue recording.

Repeat—This function allows the collection of a new feature with the same feature attributes as the previous feature. If features are not exactly the same, it also allows editing of the attributes.

Quickmark—Allows collection of point features while moving (e.g., from a car or a boat) by estimating the exact location. The use of this feature will not result in positionally accurate locations and is not recommended for most sampling operations.

Reviewing and Editing Features

It is possible to review or edit features collected in the field while still in the data capture mode. For example, it may be necessary to document the GPS location in the field logbook or to edit one of the feature's attributes. Without exiting data capture, press <REVIEW>. (If data capture is already complete, just press <REVIEW> and then select the appropriate rover file.) This step will display a list of data points including each feature collected. Scroll to the appropriate feature, and follow the steps below depending on the required action:

- To view the GPS location (e.g., lat/lon), press <POS>.
- To edit the attributes, press **ENTER**. Make any necessary edits to the attributes by scrolling through.
- To change or add an offset, press <POS> and then <OFFSET>. Make any necessary changes.
- To delete a feature collected in error, press .

Navigating to an Existing Location

Waypoints

To use the Pro XRS to navigate to a previously established position, this position must be loaded into the data logger as a waypoint, present as a feature position in the data files, or generated in the field using the GPS unit. Waypoints may be entered into the TSC1 by:

- Entering coordinates manually
- Choosing previously recorded locations and importing them into the TSC1 by using Pathfinder Office
- Defining a location stored in a rover file saved to the TSC1 as a waypoint (see *Reviewing/Editing Features*, above)
- Creating a way point from the current position being shown by the operating GPS unit in the field.

Navigating

Usually you will use the *Navigation* module (accessed by pressing **MENU** followed by **Navigation**) to guide yourself to a target (waypoint or feature). You can also use the *Map* module (accessed by pressing **MENU** followed by **Map**) to:

1. Orient yourself in the area where you are working.
2. Get a general indication of the location of a feature or waypoint that you want to find.
3. Find or select features or waypoints to which you wish to navigate toward.
4. Plot a course from one place to another.
 - a. While in the Map screen, the GPS cursor x shows the current position reported by the receiver and is always shown on the Map screen (Note: it may not always be within the visible part of the screen when panning or scrolling). The **<OPTIONS>** key can be used to hide or display the GPS trail (line of dots showing up to 60 previous positions), the heading showing the direction of travel, and other options on the map display.
 - b. Select a feature by pressing **MENU**, Data Collection to reach the *Start Feature* screen, and then **<REVIEW>** to access all features contained in the data file. Highlight and select the desired feature by pressing the **<Target>** key, which adds a crossed flag to the feature. Reaccess the *Map* screen by selecting **MENU**, then **Map**, which will now show the highlighted feature with a crossed flag symbol on the Map screen. You can then start moving toward the feature, and the current position (shown by the x) will move closer to the target position as the user approaches.

- c. There are two graphical modes of navigation with the Pro XRS in the TSC1 *Navigation* module. On both modes, text information appears on the right of the screen in the *Info* panels, which can be configured by the user. The graphical modes available are the *Directional Dial* screen or the *Road* screen, which can be toggled between using the **<Mode>** key.
- d. To navigate, select a target and then a start position. Each of these positions can be features from an open data file or a waypoint. Access a list of available features or waypoints by pressing **<TARGET>** or **<START>**. Once the item has been chosen as a target, it will show the crossed flags symbol in the list. Once a target has been selected, *Distance to Go* appears at the bottom of the *Navigation* screen, which indicates the distance from the current GPS position to the target. Select a start position (not required but useful for calculating crosstrack error and other navigation information) by pressing **<START>**. A waypoint of the current GPS position can be created for use as the Start point by selecting **<CREATE>**. Once the Start position is selected, a flag symbol will appear next to the item in the list.
- e. In the *Directional Dial* mode, an arrow will appear that will always point at the target. This is the bearing to go. (Note: You need to be moving for this to be accurate, as it will lock if you are moving too slowly or have stopped.) The triangle at the top represents the direction that you are going or heading. This triangle never moves, but by changing directions, you can line up the arrow with the triangle. When the two are aligned, you are heading in the direction of the target. When you are close to the target, a bull's-eye (two concentric circles) will appear at the edge of the screen. This is warning you that the unit will be switching to the close up screen. A proximity alarm will sound and the directional arrow will be replaced by the bull's-eye on the close up screen. Your current position will be shown by an x and the target by the bull's-eye. Move so that the x is in the same location as the bull's-eye.
- f. In the *Road* mode, navigate by walking down a road. Your position is shown by a stick figure and is always positioned in the center of the screen. The target (crossed flags) shows the point to which you are navigating toward. Your heading is shown by the top center of the screen and the bearing to go is shown by the direction of the road, which will rotate as you change your heading. Change your heading until the road is pointing at the top of the screen (*Target* is also at the top of the screen) and the edges are parallel to the sides of the screen. As you move toward the target the screen zooms in, so the road appears to get wider.

Downloading Rover Files

Upon returning to the office, download all rover files from the TSC1 to a PC for post-processing. You will need the Trimble Pathfinder software installed on your computer. If you

are not using a field laptop that already has the program installed, contact your project GIS analyst for instructions on how to install the software.

Connect the TSC1 to your computer using the appropriate cables. In addition to the “pigtail” cable, you will also need a null modem (a 9-pin female-to-female cable) to plug into a PC serial port. Once connected, power up the TSC1 unit and navigate to *MENU>File Manager>File Transfer*. Then, open the Pathfinder software and navigate to the *Utilities>Data Transfer...* window from the menu bar. Select **GIS Datalogger** on COM1 (for most computer systems), and press the green **Connect** button. Download files from the TSC1 by selecting the **Receive** tab and choosing the data file type from the *Add* pulldown menu (Figure 1).

After downloading, remove all rover files and waypoints from the TSC1 to conserve memory. Rover files may be deleted from the *File Manager* menu as follows:

1. Select **MENU>File Manager>Delete File(s)**
2. Select the rover file to be deleted, and press <ENTER>
3. Confirm the deletion of this file by pressing <YES>.

Delete data dictionaries in the same manner by selecting **Data Dictionaries** from the *File Manager* menu. Delete waypoints by selecting **Utilities** from the *Main* menu and then by selecting **Waypoints**, followed by .

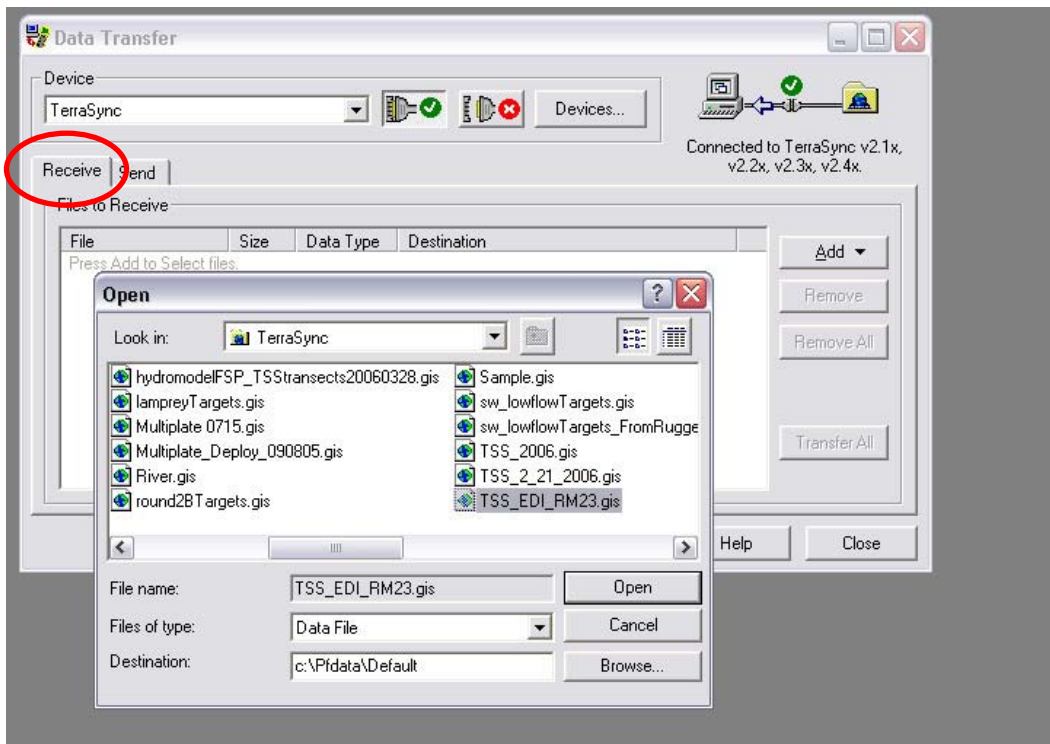


Figure 1. Transferring File from Terrasync

ATTACHMENT 2 TSC1 SETTINGS

The following are lists of menus that can be accessed through the TSC1 keypad. Please ensure that settings are correct before proceeding. Do not make changes to the settings unless necessary. Each menu will list all available subheadings, the correct setting, and the available <soft-keys> to access additional menus. Comments are included only where necessary.

GPS Rover Options

To access this menu, select **Configuration** from the main menu and then select **GPS Rover Options**. The table below lists logging options and settings.

Logging Options	Setting	Comment
<i>Logging intervals</i>		
Point feature	1s	
Line/area feature	2s–5s	depending upon speed of movement
Not in feature	None	
Velocity	None	
Confirm end feature	No	
Minimum pos	10	
Carrier Mode	Off	
Carrier phase min. time	10 minutes	
Dynamics code	Land	May be changed to sea or air, as appropriate
Audible click	Yes	
Log DOP data	Yes	
Log PPRT data	Yes	
Log QA/QC data	Yes	
Allow GPS update	Warn First	
Warning Distance	Any	
Position Mode Manual	3D	
Elevation Mask	15°	Should not go below 13° (accuracy decreases)
SNR Mask	6.0	Can raise to 7 if multi-path filtering is poor
PDOP Mask	5.0	Can be raised up to 8; reduces accuracy
PDOP Switch	6.0	

Real-Time Input Options

Access this menu from the GPS Rover *Options* menu by selecting **Real-Time Input**. The table below shows options and settings for real-time input.

Options	Setting	Comment
Preferred Correction Source	Choice 1	Integrated Beacon
	Choice 2	Integrated WAAS
	Choice 3	Use uncorrected GPS
	Correction Age Limit	20s

Antenna Options

Access this menu from the GPS rover *Options* menu by selecting **Antenna Options**. The table below shows antenna options and settings.

Option	Setting	Comment
Height	6 ft	Enter correct user antenna height using measurement method indicated below
Measure Type	Uncorrected	
Confirm	Integrated GPS/Beacon/Satellite	
Part Number	Per file	Can be changed to "Per feature" if antenna height varies and elevation is critical
Measurement Method	33580-50	Auto selected based on TYPE selected
	Bottom of Antenna	
	Mount	

ATTACHMENT 3

ADDITIONAL SETTINGS FOR THE TSC1

Additional TSC1 settings can be found in the *Configuration* menu. Items of particular importance are indicated in italics.

Configuration

This menu can be accessed by selecting **Configuration** from the main menu. The table below lists options and descriptions for the *Configuration* menu.

Options	Description
GPS base station options	For using a land base station or beacon for real time corrections
NMEA/TSIP output	Consult manual
Coordinate system	Changes coordinate system among latitude/longitude, UTM, and other coordinate systems. System can be converted, if necessary, after data capture by using Pathfinder Office software.
Map Display options	Change layers, scale, background files and items shown on the TSC1 screen during data collection
Navigation options	Changes Navigation parameters
Units and display	Changes various units, for example: length (e.g., feet, meters), altitude reference (e.g., MSL), <i>North reference</i> (i.e., true or magnetic). Units can be converted, if necessary, after data capture by using Pathfinder Office software.
Time and date	Changes to <i>local time</i> , 24-hour clock, date format, and other options
Quickmarks	Set-up parameters for use with Quickmarks.
Constant offset	Set-up parameters for use with a constant offset.
External sensors	Connections with external sensors.
Hardware (TSC1)	TSC1 settings such as beep volume, contrast, <i>internal and external battery status</i> , software version, free space.

Contrast and Backlighting

The TSC1 display can be viewed in various light settings. Press **FUNC**, then **L** to turn on the display backlight for viewing in dim lighting. Adjust the contrast by pressing **FUNC**, then **E** or **F**.

ATTACHMENT 4

PRE-SAMPLING ACTIVITIES BEFORE USE OF THE PRO XRS

Determination of Optimal Satellite-Use Time

Positioning accuracies on the order of ± 1 to 3 m can be achieved by avoiding the few minutes per day when the satellites are not providing the same level of signal. The GPS unit provides the operator with a listing of the time intervals during the day when accuracies are decreased. Avoiding these time intervals permits the operator to maintain better positioning accuracy.

ATTACHMENT 5

MANAGING GPS DATA FROM TERRASYNC—A TUTORIAL

Currently, positional data collected in the field is most often done with a Trimble GPS unit (usually rented) interfaced with a laptop via Trimble's Terrasync software. The Terrasync software sometimes exhibits quirks that interfere with the smooth operation of data collection in otherwise stressful field conditions. This tutorial is meant to supplement the Terrasync software documentation and serve as a guide to field personnel to help them retrieve and collect geographic data as efficiently as possible with existing software.

Scope

This document is intended to be a reference for procedures involving the following:

- Fixing files that are more than 7 days old so that they can be updated
- Adding features in GPS Pathfinder software (companion to Terrasync) and then importing them as base files in Terrasync..

This document is not intended to be a comprehensive manual for using Terrasync or Pathfinder software. It is assumed that the reader has received at least some training on how to use the basic features of Terrasync and is competent at using MS Windows.

The Basics

GPS data collection currently relies on two pieces of complementary software:

- Terrasync—the interface for GPS navigation and data collection.
- Pathfinder Office—a multiuse piece of software that acts as a conduit between GIS data files (shape files) and Terrasync GPS files. Pathfinder can also be used as a simple map editor.

Installing the Correct Versions of Terrasync and Pathfinder

Important Note: This tutorial uses Pathfinder Office v. 3.00 and Terrasync v. 2.50. It is very important to use the proper versions of this software to avoid compatibility issues. These software versions should be included in the same folder as this tutorial, or can be obtained from GIS staff.

http://www.trimble.com/terrasync_ts.asp?Nav=Collection-4576

Key code for TerraSync
499043-00110-05273-EDD049BC

Pathfinder v.3.00
001533-00300-04152-0ee4d11f

Initial Setup of Terrasync/Pathfinder

Certain settings and configuration setups are needed before Pathfinder can talk to Terrasync. Whether you are installing this software for the first time or have an existing installation, check to make sure that these settings are in place.

1. Open Pathfinder Office and go to the *Utilities>Data Transfer...* menu. A dialog box should appear. This is the interface for communicating with Terrasync.
2. Click the **Devices** button, and then **New...** (Figure 1).
3. Click on **GIS Folder**.
4. Browse to the Terrasync data folder on your computer, which in most cases will be *C:\My Documents\TerraSync*.
5. In the next box, *Type* will be **Terrasync**, and *Version* will be **v. 2.1x, v.2.2x, v.2.3x, and v2.4x**.
6. At the prompt for a name that will display in the device list, enter **Terrasync**.
7. Go back to the Data Transfer dialog box, select **Terrasync** from the dropdown menu, press the **Connect** icon, and look for a green check mark indicating success.

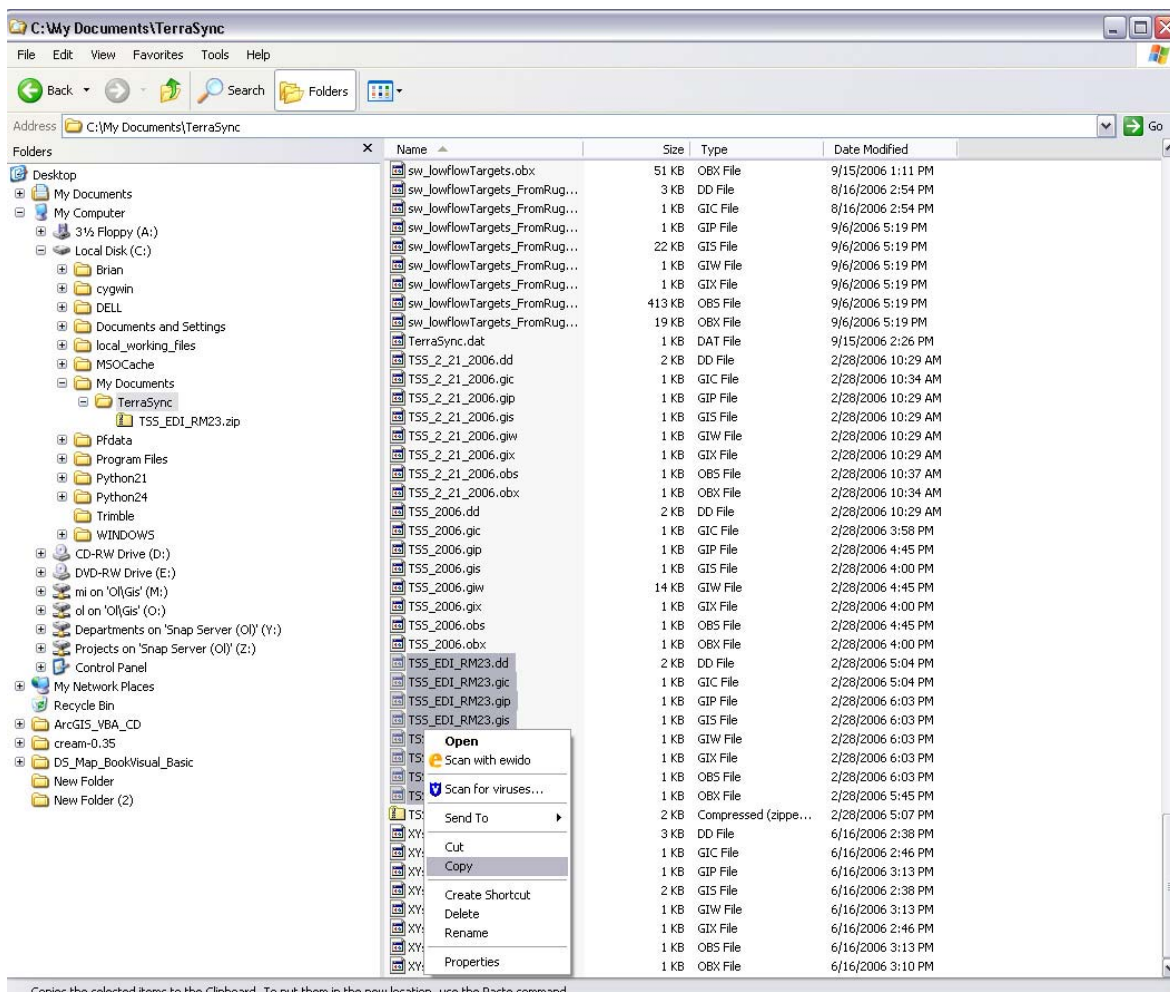


Figure 2. Selecting Files To Copy to a Different Directory

If this procedure does not work for you, you may have the wrong version of Pathfinder. For some unknown reason, with each version upgrade of Pathfinder, connectivity to older versions of Terrasync is lost. You can check what version of Pathfinder you have installed by going to the *Help>About GPS Pathfinder Office...* menu. To find out what version of Terrasync you have, go to *C:\Program Files\TerraSync*, right-click on **Terrasync.exe**, and choose the **Version** tab.

Handling Expired Files in Terrasync

One of the most common problems that field personnel will have to deal with is the 1-week expiration date when trying to collect data with Terrasync. This is a built-in function of Terrasync, and there is no simple way to work around it. The following instructions will guide you through the process to make the files usable. See Figure 3.

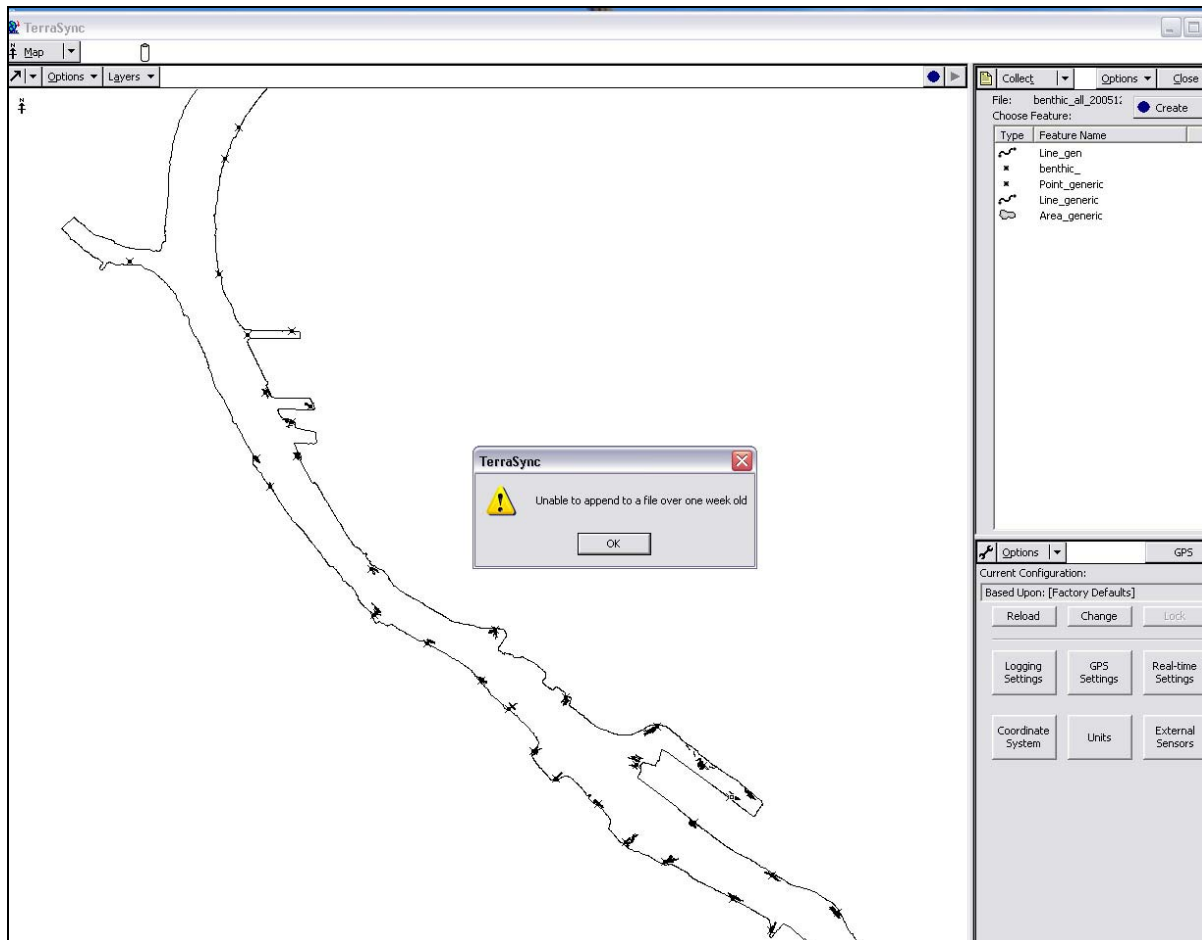


Figure 3. Notice That Terrasync File Older Than 1 Week Will Not Allow User To Collect Features (time begins to elapse when first feature is collected in the field, not when file is created)

Two options are available, depending on your needs. If you do not need to see the previously logged locations and need only to see the targets, use the original files provided by GIS staff (Option 1). If you need to see previously occupied locations in order to make decisions about where to go next, then transfer the file to Pathfinder and back again (Option 2).

Option 1: Move and replace logged files with original targets.

At the beginning of the field effort, you should receive a set of files with the target locations, most likely in a zip archive (.zip file extension). There will be six to eight files with the same name but with different extensions (Figure 4). These files will have to go into the C:\My Documents\TerraSync\ folder in order to be available to Terrasync.

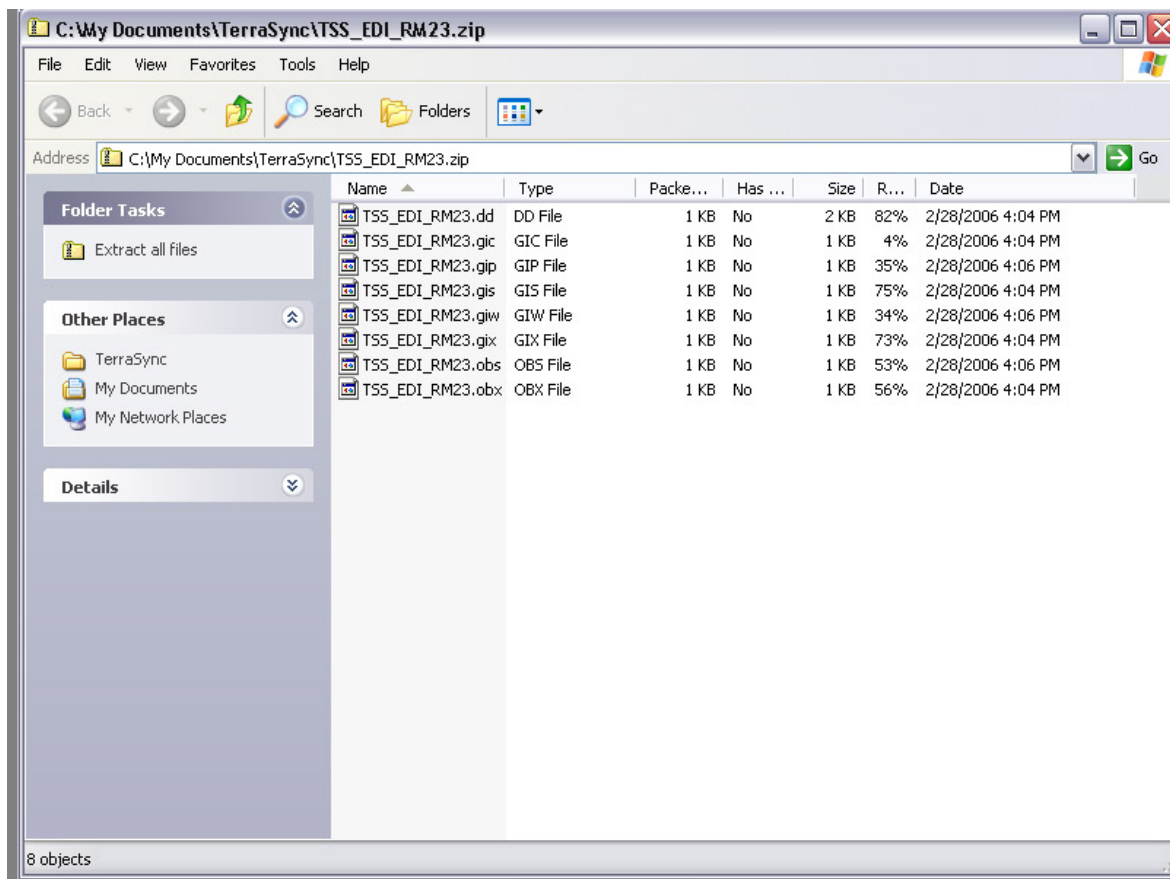


Figure 4. Example of File Set To Be Unzipped into the Terrasync Folder

After you unzip these files to Terrasync, keep this zip archive around in an easy-to-find place, such as your computer desktop, because the 1-week clock does not start until you begin collecting your first point in the field. You can use this unadulterated file again, as long as you make a copy of the work you did the previous week. The detailed steps are as follows:

1. Make sure you have the original files with the target locations available in a handy place. This will probably be the original zip archive. Also, be sure to close Terrasync while performing this process.
2. Navigate to C:\My Documents\TerraSync\ in Windows Explorer. Locate the files that you have been using the previous week. Note: It is crucial to get all of the small files associated with the data set. While it is useful to sort the files by date modified, you can miss some of the small files—it is highly recommended that you sort the files alphabetically.

3. Copy all of these files to a different directory, preferably one that is named appropriately to reflect the data and time period that you were collecting. For example: C:\Documents and Settings\bpointer\Desktop\lampreyTargets_20060925. These files contain the data you have collected the previous week and should be backed up and/or emailed to the appropriate project manager or GIS staff.
4. You can now safely replace the files you just copied with the ones from the original zip file. Right-click the zip archive, and click Extract All. When prompted to Select a folder to extract files to, browse to C:\My Documents\TerraSync. (Figure 5). If prompted about replacing existing files, select Yes to All. Note: It is crucial to make copies of the files first (see Step 3 above)—otherwise, you may lose the data.
5. You should now be able to open the file in Terrasync and begin logging as normal.

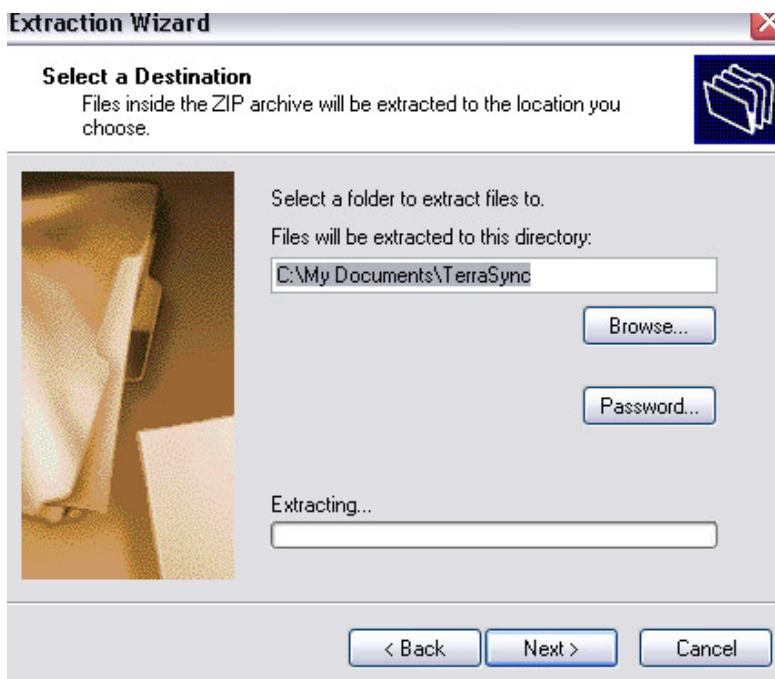


Figure 5. Extract (or copy) Original Target Files into the Terrasync Directory

Option 2: Transfer files back and forth from Terrasync.

If you need to be able to see the previously occupied positions from last week while positioning this week, you need to use Pathfinder to reset the file. This process will essentially combine the targets and actuals from last week into one file. However, this method has its drawbacks; once converted, the actuals from last week will not be able to be corrected, so a backup procedure similar to the one in the previous option should be carried out to maintain data integrity.

The steps for file transfer are as follows:

1. For good data management, back up the data files from the previous week using the procedure laid out in steps 1 through 3 in Option 1 above.
2. Close Terrasync and open up Pathfinder Office.
3. Go to the Utilities>Data Transfer menu or just click the icon on the left (Figure 6).
4. Ensure that the device listed is Terrasync. If not, follow the initial setup instructions at the beginning of this document. Most of the computers used for GPS logging are already setup for this.
5. There are two tabs, Receive and Send. Make sure that Receive is selected and then go to Add>Data File. Select the file(s) that you are using and select Open. The file should now be in the Files to Receive box. Click Transfer All and wait for the transfer to take place. If you have made the recommended backups, it is fine to replace any files.
6. Now select the Send tab (Figure 7), and go to Add>Data File. Select the file you just transferred (it will have the same name as the Terrasync file) and click Open. Now click Transfer All to move the file back to Terrasync.

By transferring the file back and forth from Terrasync to Pathfinder, you have “reset the clock” and can now update the file for an additional 7 days. This file will have your targets and actual positions from the last week, so it is important to be aware of the features you are selecting for navigation.

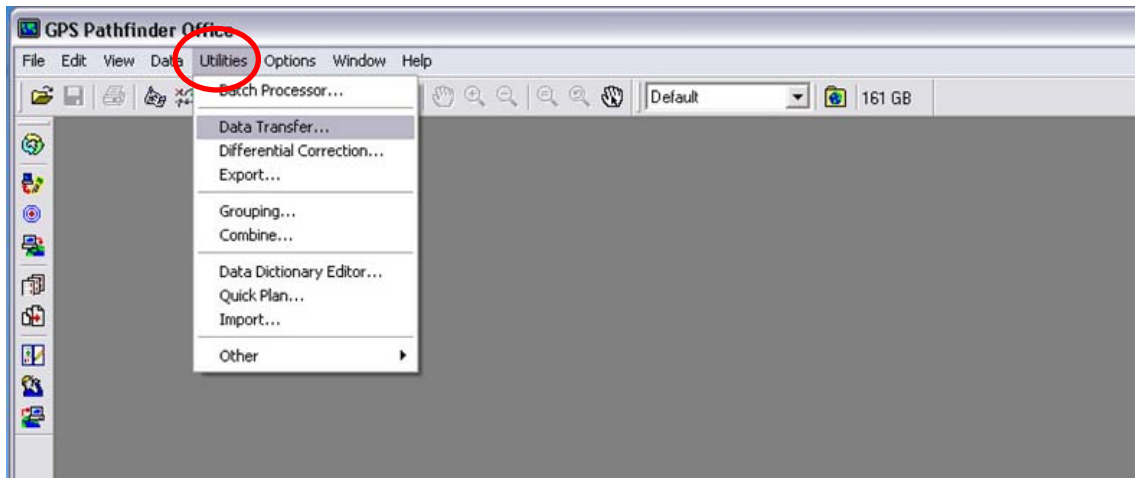


Figure 6. Data Transfer Menu

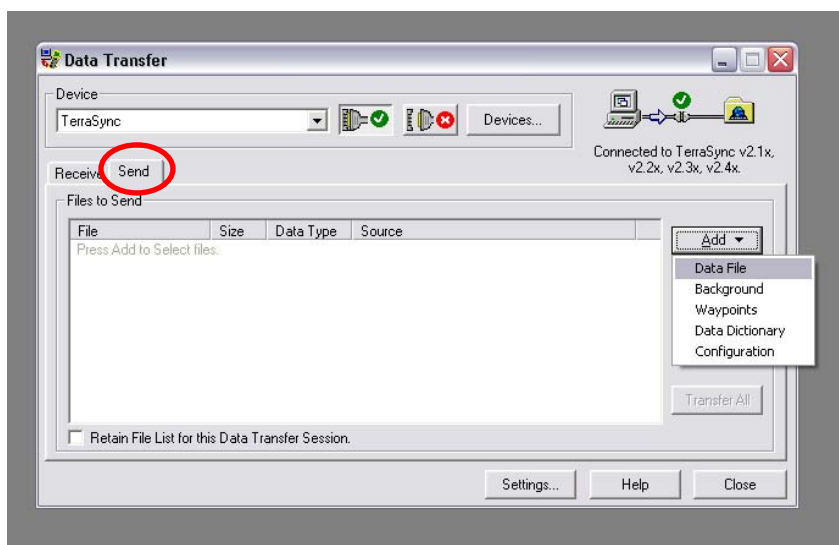


Figure 7. Sending Data File

STANDARD OPERATING PROCEDURE (SOP) SD-01

DECONTAMINATION OF SEDIMENT SAMPLING EQUIPMENT

SCOPE AND APPLICATION

This SOP describes procedures for decontaminating sampling and processing equipment contaminated by either inorganic or organic materials. To prevent potential cross contamination of samples, all reusable sediment sampling and processing equipment is decontaminated before each use. At the sample collection site, a decontamination area is established in a clean location that is upwind of actual sampling locations, if possible. All sediment sampling and processing equipment is cleaned in this location. Decontaminated equipment is stored away from areas that may cause recontamination. When handling decontamination chemicals, field personnel must follow all relevant procedures and wear protective clothing as stipulated in the site-specific health and safety plan (HSP).

Sampling equipment (e.g., van Veen, Ekman, Ponar, core tubes) may be used to collect samples that will 1) undergo a full-suite analysis (organics, metals, and conventional parameters) or 2) be analyzed for metals and conventional parameters only. Decontamination of sampling equipment used for both analyte groups should follow the order of a detergent wash, site water rinse, organic solvent rinses, and final site water rinse. Sample processing equipment (e.g., bowls, spoons) has a final rinse with distilled/deionized water rinse instead of site water. If the surface of stainless steel equipment appears to be rusting (possibly due to prolonged contact with organic-rich sediment), it should undergo an acid rinse and a site-water rinse at the end of each sampling day to minimize corrosion.

EQUIPMENT AND REAGENTS REQUIRED

Equipment required for decontamination includes the following:

- Polyethylene or polypropylene tub (to collect solvent rinsate)
- Plastic bucket(s) (e.g., 5-gal bucket)
- Tap water or site water
- Carboy, distilled/deionized water (analyte-free; received from testing laboratory or other reliable source)
- Properly labeled squirt bottles

- Funnels
- Alconox®, Liquinox®, or equivalent industrial detergent
- Pesticide-grade acetone and hexane (consult the project-specific field sampling plan [FSP], as the solvents may vary by EPA region or state)
- 10 percent (v/v) nitric acid (reagent grade) for inorganic contaminants
- Baking soda
- Long-handled, hard-bristle brushes
- Extension arm for cleaning core liners
- Plastic sheeting, garbage bags, and aluminum foil
- Core liner caps or plastic wrap and rubber bands
- Personal protective equipment as specified in the health and safety plan.

PROCEDURES

Decontamination Procedures for Full Suite Analysis (Organic, Metal, or Conventional Parameters)

Two organic solvents are used in this procedure. The first is miscible with water (e.g., ethanol) and is intended to scavenge water from the surface of the sampling equipment and allow the equipment to dry quickly. This allows the second solvent to fully contact the surface of the sampler. Make sure that the solvent ordered is anhydrous or has a very low water content (i.e., < 1 percent). If ethanol is used, make sure that the denaturing agent in the alcohol is not an analyte in the samples. The second organic solvent is hydrophobic (e.g., hexane) and is intended to dissolve any organic chemicals that are on the surface of the equipment.

The exact solvents used for a given project may vary by EPA region or state (see project-specific FSP). Integral uses ethanol and hexane as preferred solvents for equipment decontamination. If specified in the project-specific FSP, isopropanol or acetone can be substituted for ethanol, and methanol can be substituted for hexane in the decontamination sequence. The choice of solvents is also dependent on the kind of material from which the equipment is made (e.g., acetone cannot be used on polycarbonate), and the ambient temperature (e.g., hexane is too volatile in hot climates). In addition, although methanol is sometimes slightly more effective than other solvents, its use is discouraged due to potential toxicity to sampling personnel.

The specific procedures for decontaminating sediment sampling equipment and sediment compositing equipment are as follows:

1. Rinse the equipment thoroughly with tap or site water to remove visible sediment. Perform this step onsite for all equipment, including core liners that will not be used again until the next day of sampling. After removing visible solids, set aside sampling equipment that does not need to be used again that day; this equipment should be thoroughly cleaned in the field laboratory at the end of the day.
2. Pour a small amount of concentrated laboratory detergent into a bucket (i.e., about 1–2 tablespoons per 5-gal bucket) and fill it halfway with tap or site water. If the detergent is in crystal form, make sure all crystals are completely dissolved prior to use.
3. Scrub the equipment in the detergent solution using a long-handled brush with rigid bristles. For the polycarbonate core liners, use a round brush attached to an extension arm to reach the entire inside of the liners, scrubbing with a back-and-forth motion. Be sure to clean the outside of core liners, bowls, and other pieces that may be covered with sediment.
4. Double rinse the equipment with tap or site water and set right-side-up on a stable surface to drain. The more completely the equipment drains, the less solvent will be needed in the next step. Do not allow any surface that will come in contact with the sample to touch any contaminated surface.
5. If the surface of stainless steel equipment appears to be rusting (this will occur during prolonged use in anoxic marine sediments), passivate¹ the surface as follows (if no rust is present, skip to next step). Rinse with a 10 percent (v/v) nitric acid solution using a squirt bottle, or wipe all surfaces using a saturated paper towel. Areas showing rust may require some rubbing with the paper towel. If using a squirt bottle, let the excess acid drain into the waste container (which may need to be equipped with a funnel). Double-rinse equipment with tap or site water and set right-side-up on a stable surface to drain thoroughly.
6. Carefully rinse the equipment with ethanol from a squirt bottle, and let the excess solvent drain into a waste container (which may need to be equipped with a funnel). Hold core liners over the waste container and turn them slowly so the stream of solvent contacts the entire surface. Turn the sample apparatus (e.g., grab sampler) on its side and open it to wash it most effectively. Set the equipment in a clean location and allow it to air dry. Use only enough solvent to scavenge all of the water and flow off the surface of the equipment (i.e., establish sheet flow) into the waste container. Allow equipment to drain as much as possible. Ideally, the equipment will be dry. The more thoroughly it drains, the less solvent will be needed in the next step.

¹ Passivation is the process of making a material less reactive relative to another material. For example, before sediment is placed in a stainless-steel container, the container can be passivated by rinsing it with a dilute solution of nitric acid and deionized water.

7. Carefully rinse the drained or air-dried equipment with hexane from a squirt bottle, and let the excess solvent drain into the waste container (which may need to be equipped with a funnel). If necessary, widen the opening of the squirt bottle to allow enough solvent to run through the core liners without evaporating. (Hexane acts as the primary solvent of organic chemicals. Ethanol is soluble in hexane but water is not. If water beading occurs, it means that the equipment was not thoroughly rinsed with acetone or that the acetone that was purchased was not free of water.) When the equipment has been rinsed with hexane, set it in a clean location and allow the hexane to evaporate before using the equipment for sampling. Use only enough solvent to scavenge all of the acetone and flow off the surface of the equipment (i.e., establish sheet flow) into the waste container.
8. Do a final rinse with site water for the sampling equipment (i.e., van Veen, Ekman, Ponar, core tubes) and with distilled/deionized water for processing equipment (i.e., stainless-steel bowls and spoons). Equipment does not need to be dried before use.
9. If the decontaminated sampling equipment is not to be used immediately, wrap small stainless-steel items in aluminum foil (dull side facing the cleaned area). Seal the polycarbonate core liners at both ends with either core caps or cellophane plastic and rubber bands. Close the jaws of the Ekman and Ponar grab samplers and wrap in aluminum foil.

If the sample collection or processing equipment is cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag (e.g., a trash bag) until ready for use, unless the project-specific FSP lists special handling procedures.

10. Rinse or wipe with a wetted paper towel all stainless-steel equipment at the end of each sampling day with 10 percent (v/v) normal nitric acid solution. Follow with a freshwater rinse (site water is okay as long as it is not brackish or salt water).
11. After decontaminating all of the sampling equipment, place the disposable gloves and used foil in garbage bags for disposal in a solid waste landfill. When not in use, keep the waste solvent container closed and store in a secure area. The waste should be transferred to empty solvent bottles and disposed of at a licensed facility per the procedures listed in the project-specific FSP. When not in use, keep the waste acid container closed and store in a secure area. The acid waste should be neutralized with baking soda and disposed of per the procedures listed in the project-specific FSP.

Decontamination Procedures for Metals and Conventional Parameters Only

The specific procedures for decontaminating sediment sampling equipment and sediment processing equipment are as follows:

1. Rinse the equipment thoroughly with tap or site water to remove the visible sediment. Perform this step onsite for all equipment, including core liners that will not be used again until the next day of sampling. Set aside pieces that do not need to be used again that day; these pieces should be and thoroughly cleaned in the field laboratory at the end of the day.
2. Pour a small amount of concentrated laboratory detergent into a bucket (i.e., about 1–2 tablespoons per 5-gal bucket) and fill it halfway with tap or site water. If the detergent is in crystal form, make sure all crystals are completely dissolved prior to use.
3. Scrub the equipment in the detergent solution using a long-handled brush with rigid bristles. For the polycarbonate core liners, use a round brush attached to an extension arm to reach the entire inside of the liners, scrubbing with a back-and-forth motion. Be sure to clean the outside of core liners, bowls, and other pieces that may be covered with sediment.
4. Double-rinse the equipment with tap or site water and set right-side-up on a stable surface to drain. Do not allow any surface that will come in contact with the sample to touch any contaminated surface.
5. If the surface of stainless steel equipment appears to be rusting (this will occur during prolonged use in anoxic marine sediments), passivate² the surface as follows (if no rust is present, skip to next step). Rinse with a 10 percent (v/v) nitric acid solution using a squirt bottle, or wipe all surfaces using a saturated paper towel. Areas showing rust may require some rubbing with the paper towel. If using a squirt bottle, let the excess acid drain into the waste container (which may need to be equipped with a funnel). Double-rinse sampling equipment with tap or site water and set right-side-up on a stable surface to drain. Double-rinse processing equipment with distilled/deionized water and allow to drain.
6. If the decontaminated sampling equipment is not to be used immediately, wrap small stainless-steel items in aluminum foil (dull side facing the cleaned area). Seal the polycarbonate core liners at both ends with either core caps or cellophane plastic and rubber bands. Close the jaws of the Ekman and Ponar grab samplers and wrap in aluminum foil.

If the sample collecting or processing equipment is cleaned at the field laboratory and transported to the site, then the decontaminated equipment will be wrapped in aluminum foil (dull side facing the cleaned area) and stored and transported in a clean plastic bag until ready for use, unless the project-specific FSP lists special handling procedures.

² Passivation is the process of making a material less reactive relative to another material. For example, before sediment is placed in a stainless-steel container, the container can be passivated by rinsing it with a dilute solution of nitric acid and deionized water.

7. After decontaminating all of the sampling equipment, place the disposable gloves and used foil in garbage bags for disposal in a solid waste landfill. When not in use, keep the waste acid container closed and store in a secure area. The acid waste should be neutralized with baking soda and disposed of per the procedures listed in the project-specific FSP.

STANDARD OPERATING PROCEDURE (SOP) SD-02

PREPARATION OF FIELD QUALITY CONTROL SAMPLES FOR SEDIMENTS

SCOPE AND APPLICATION

This SOP describes the purpose, preparation, and collection frequency of field duplicate samples, field replicate samples, matrix spike/matrix spike duplicates, equipment rinsate blanks, bottle blanks, trip blanks, temperature blanks, environmental blanks, and reference materials (i.e., a standard reference material, a certified reference material, or other reference material; for the purposes herein, all types of reference materials are referred to as standard reference material, or SRM) for sediment sampling efforts. Not all of the field quality control samples discussed in this SOP may be required for a given project. The specific field quality control samples will be identified in the project-specific field sampling plan (FSP) and quality assurance project plan (QAPP). For most projects, Integral's recommended field quality control samples are an equipment rinsate blank, a field duplicate, and trip blanks if samples are to be analyzed for volatile organic compounds (VOCs). Definitions of all potential quality control samples are described below.

As part of the quality assurance/quality control (QA/QC) program, all field quality control samples will be sent to the laboratories "blind." To accomplish this, field quality control samples will be prepared and labeled in the same manner as regular samples, with each quality control sample being assigned a unique sample number that is consistent with the numbering for regular samples. All of the containers with preservatives that are required to complete the field quality control sample for the applicable analyte list shall be labeled with the same sample number. The sample ID for field quality control samples should allow data management and data validation staff to identify them as such and should be recorded only in the field logbook. Under no circumstances should the laboratory be allowed to use reference materials, rinsate blanks, or trip blanks for laboratory quality control analysis (i.e., duplicates, matrix spike, and matrix spike duplicates). To prevent such an occurrence, regular samples should be selected and marked on the chain-of-custody/sampling analysis request (COC/SAR) form or the laboratory should be instructed to contact the project QA/QC coordinator to select appropriate samples for each sample group.

Field quality control samples will be prepared at least once per sampling event, and certain types will be prepared more often at predetermined frequencies. If the number of samples taken does not equal an integer multiple of the intervals specified in this SOP, the number of

field quality control samples is specified by the next higher multiple. For example, if a frequency of 1 quality control sample per 20 is indicated and 28 samples are collected, 2 quality control samples will be prepared. Field quality control samples for sediment sampling activities should be prepared consistent with the requirements discussed below and at the frequency indicated unless different frequency requirements are listed in the FSP and QAPP.

The following table lists the quality control sample types and suggested frequencies for sediment sampling programs. Because sediment quality control sampling may require assessment of site cross-contamination, additional blanks may be required. A detailed explanation of each quality control sample type with the required preparation follows.

Table 1. Field Quality Control Sample Requirements

Quality Control Sample Name	Abbreviation	Preparation		Frequency ^a
		Location	Method	
Duplicate	DUP	Sampling site	Additional natural sample	One per 20 samples. May not be applicable if REP is being collected.
Replicate	REP	Sampling site	Additional natural sample	One replicate per 20 samples. May not be applicable if DUP is being collected.
Matrix spike/matrix spike duplicate	MS/MSD	Sampling site	Additional sample bottles filled for laboratory quality control requirements	One per 20 samples.
Equipment rinsate blank	ER	Sampling site	Deionized water collected after pouring through and over decontaminated equipment	Minimum of one per sampling event per type of sampling equipment used and then 1 per 20 thereafter.
Bottle blank	BB	Field	Unopened bottle	One per sample episode or one per bottle type.
Trip blank	TB	Laboratory	Deionized water with preservative	One pair per each VOC sample cooler shipment.
Temperature blank	TMB	Laboratory	Deionized water	One per sample cooler.
Environmental blank	EB	Field	Bottle filled at sample site with deionized water	One per 20 samples.
Standard reference material	SRM	Field laboratory or sampling site	SRM ampules or other containers for each analyte group	One set per 50 samples or one per episode.

^a Frequencies provided here are general recommendations; specific frequencies should be provided in the project-specific FSP or QAPP.

FIELD DUPLICATE SAMPLES

Field duplicate (or split) samples are collected to assess the homogeneity of the samples collected in the field and the precision of the sampling process. Field duplicates will be prepared by collecting two aliquots for the sample and submitting them for analysis as separate samples. Field duplicates will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. The actual number of field duplicate samples collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of field duplicate collection may vary by EPA region or state).

FIELD REPLICATE SAMPLES

Field replicate samples are co-located samples collected in an identical manner over a minimum period of time to provide a measure of the field and laboratory variance, including variance resulting from sample heterogeneity. Field replicates will be prepared by collecting two completely separate samples from the same station and submitting them for analysis as separate samples. Field replicates will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. If field duplicate samples are collected, then it is unlikely that field replicate samples will also be collected during a sampling event. The actual number of field replicate samples collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of field duplicate collection may vary by EPA region or state).

MATRIX SPIKE/MATRIX SPIKE DUPLICATES

The matrix spike/matrix spike duplicate (MS/MSD) analyses provide information about the effect of the sample matrix on the design and measurement methodology used by the laboratory. To account for the additional volume needed by the laboratory to perform the analyses, extra sample volumes may be required to be collected from designated sediment stations. MS/MSDs may be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent. The actual number of extra bottles collected during a sampling event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements may vary by analyte group).

EQUIPMENT RINSATE BLANKS

Equipment rinsate blanks will be used to help identify possible contamination from the sampling environment and/or from decontaminated sampling equipment. Equipment rinsate blanks will be prepared by pouring laboratory distilled/deionized water through, over, and into the decontaminated sample collection equipment, and then transferring the water to the appropriate sample containers and adding any necessary preservatives. Equipment rinsate blanks will be prepared for all inorganic, organic, and conventional analytes at least once per sampling event per the type of sampling equipment used. The actual number of equipment rinsate blanks prepared during an event will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of equipment rinsate blank collection may vary by EPA region or state).

BOTTLE BLANKS

The bottle blank is an unopened sample bottle. Bottle blanks are submitted along with sediment samples to ensure that contaminants are not originating from the bottles themselves because of improper preparation, handling, or cleaning techniques. If required, one bottle blank per lot of prepared bottles will be submitted for analysis. If more than one type of bottle will be used in the sampling (e.g., high-density polyethylene or glass), then a bottle blank should be submitted for each type of bottle and preservative. The actual number of bottle blanks analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP as the requirements on frequency of bottle blank analysis may vary by EPA region or state).

To prepare a bottle blank in the field, set aside one unopened sample bottle from each bottle lot sent from the testing laboratory. Label the bottle as “Bottle Blank” on the sample label (and in the “Remarks” column on the COC/SAR form), and send the empty bottle to the laboratory with the field samples.

TRIP BLANKS

Trip blanks will be used to help identify whether contaminants may have been introduced during the shipment of the sediment samples from the field to the laboratory for VOC analyses only. Trip blanks are prepared at the testing laboratory by pouring distilled/deionized water into two 40-mL VOC vials and tightly closing the lids. Each vial will be inverted and tapped lightly to ensure no air bubbles exist.

The trip blanks will be transported unopened to and from the field in the cooler with the VOC samples. A trip blank is labeled and placed inside the cooler that contains newly collected VOC samples and it remains in the cooler at all times. A trip blank must accompany samples

at all times in the field. One trip blank (consisting of a pair of VOC vials) will be sent with each cooler of samples shipped to the testing laboratory for VOC analysis.

TEMPERATURE BLANKS

Temperature blanks will be used by the laboratory to verify the temperature of the samples upon receipt at the testing laboratory. Temperature blanks will be prepared at the testing laboratory by pouring distilled/deionized water into a vial and tightly closing the lid. The blanks will be transported unopened to and from the field in the cooler with the sample containers. A temperature blank shall be included with each sample cooler shipped to the testing laboratory.

FIELD BLANKS

The field blank is prepared in the field to evaluate potential background concentrations present in the air and in the distilled/deionized water used for the final decontamination rinse. If unpreserved bottles are to be used, then the appropriate preservative (i.e., for metals samples use a 10 percent nitric acid solution to bring sample pH to 2 or less) must be added, as may be required. Field blanks should be collected at a minimum frequency of 1 in 20 samples. The actual number of field blanks analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of field blank analysis may vary by EPA region or state).

To prepare a field blank in the field, open the laboratory-prepared sample bottle while at a sample collection site, fill the sample bottle with distilled/deionized water, and then seal it. Assign the field blank a unique sample number, label the bottle, and then send the bottle to the laboratory with the field samples.

REFERENCE MATERIALS

SRMs are samples containing known analytes at known concentrations that have been prepared by and obtained from EPA-approved sources. The SRMs have undergone multi-laboratory analyses using a standard method that provides certified concentrations. When available for a specific analyte, SRMs provide a measure of analytical performance and/or analytical method bias (i.e., accuracy) of the laboratory. Several SRMs may be required to cover all analytical parameters. For all analytes where available, one SRM will be analyzed at a frequency of one per 50 samples. The actual number of SRMs analyzed during a project will be determined on a case-by-case basis by the project QA/QC coordinator (consult the project-specific FSP and QAPP, as the requirements on frequency of SRM analysis may vary by EPA region or state).

STANDARD OPERATING PROCEDURE (SOP) SD-04

SURFACE SEDIMENT SAMPLING

SCOPE AND APPLICATION

This SOP defines and standardizes the methods for collecting surface sediment samples from freshwater or marine environments. Surface sediments are defined as those from 0 to at most 10 cm below the sediment-water interface. The actual definition of surface sediments is typically program-specific and depends on the purpose of the study and the regulatory criteria (if any) to which the data will be compared.

This SOP utilizes and augments the procedures outlined in USEPA (1996) and ASTM (2003) guidelines. A goal of this SOP is to ensure that the highest quality, most representative data are collected, and that these data are comparable to data collected by different programs that follow the USEPA (1996) guidelines.

SUMMARY OF METHOD

Sediment samples for chemical and toxicity analysis are collected using a surface sediment sampling device (e.g., grab sampler). If a sample meets acceptability guidelines, overlying water is carefully siphoned off the surface, and the sediment is described in the field log. Sediment samples for chemical analysis may be collected directly from the sampler (e.g., volatile organic compounds and sulfides), or sediment from the sampler may be homogenized using decontaminated, stainless-steel containers and utensils prior to being placed in sample jars. Sediment from several sampler casts may also be composited and homogenized prior to being placed in sample jars.

SUPPLIES AND EQUIPMENT

A generalized supply and equipment list appears below. Additional equipment may be required depending on project requirements.

- Grab sampler or box corer (see examples below in procedures for "Sediment Sample Collection")
- Field equipment
 - Siphoning hose

- Stainless-steel bowls or containers
- Stainless-steel spoons, spatulas, and/or mixer
- Project-specific decontamination supplies (e.g., Alconox™ detergent, 0.1 N nitric acid, methanol, hexane, distilled/deionized water)
- Personal protective equipment for field team (e.g., rain gear, safety goggles, hard hats, nitrile gloves)
- First aid kit
- Cell phone
- Camera
- Sample containers
- Bubble wrap
- Sample jar labels
- Clear tape
- Permanent markers
- Indelible black-ink pens
- Pencils
- Coolers
- Ice
- Documentation
 - Waterproof field logbook
 - Field sampling plan
 - Health and safety plan
 - Correction forms
 - Request for change forms
 - Waterproof sample description forms.

PROCEDURES

Sediment Sample Collection

Use a sampler that obtains a quantifiable volume of sediment with minimal disturbance of the surrounding sediments to collect sediment for chemical and biological analyses. The sampler

should be composed of a material such as stainless steel or aluminum, or have a noncontaminating coating such as Teflon™. Samplers capable of providing high-quality sediment samples include grab-type samplers (e.g., van Veen, Ekman, Smith-McIntyre, Young grab, Power Grab and modified-ponar grab) and box cores (Soutar, mini-Soutar, Gray-O'Hara, spade core). Some programs require a sampler that collects from a specific area (e.g., 0.1 m²). Most sampling devices are typically a standard size; however, some non-standard sizes are available to meet the requirements of specific programs. Grab samplers, especially van Veen grab and Ekman grab, are the most commonly used samplers to collect surface sediment. Power Grab samplers are often used for programs requiring collection of sediment deeper than 10 cm (4 in.) or in areas with debris.

Depending on grab weight and water depth, use a hydraulic winch system to deploy the heavier samplers at a rate not exceeding 1 m/second to minimize the bow wake associated with sampler descent. Once the sampler hits the bottom, close the jaws slowly and bring the sampler to the deck of the vessel at a rate not exceeding 1 m/second to minimize any washing and disturbance of the sediment within the sampler. At the moment the sampler hits the bottom, record the time, depth, and location of sample acquisition in the field logbook.

Retrieve and secure the sampler, and carefully siphon off any overlying water. Inspect the sample to determine acceptability using the criteria detailed in PSEP (1996), except when noted in the project-specific field safety plan. These criteria include but are not limited to the following:

- There is minimal or no excessive water leakage from the jaws of the sampler
- There is no excessive turbidity in the water overlying the sample
- The sampler is not over-penetrated
- The sediment surface appears to be intact with minimal disturbance
- The program-specified penetration depths are attained.

If the sample meets acceptability criteria, record the sample and enter observations onto a sample description form or log. Once the sample has been characterized, subsample the sediment for chemical and biological analyses.

Sample Processing

Using a stainless-steel spoon, remove from the sediment from the sampler for chemical and/or toxicity analyses. Depending on programmatic goals, remove the upper 10 cm (4 in.) of sediment. To prevent possible cross-contamination, do not use sediments touching the margins of the sampler.

Complete all sample logs, labels, custody seals, and chain-of-custody forms, and record sample information in the field notebook.

Collect samples for volatile compounds (either organics or sulfides) using a decontaminated stainless-steel spoon while sediment is still in the sampler. These sediments are not homogenized. Tightly pack the volatile organics sample jar with sediment (to eliminate obvious air pockets) and fill it so that no headspace remains in the jar. Alternatively, if there is adequate water in the sediment, fill the container to overflowing so that a convex meniscus forms at the top, and then carefully place the cap on the jar. Once sealed, the jar should contain no air bubbles.

Place the remaining sediment in a precleaned, stainless-steel bowl. Typically, sediment from a minimum of three separate casts of the sampler is composited at each station. Once you have collected a sufficient amount of sediment, mix the sediment until it is of uniform color and smooth consistency. Dispense the sediment into precleaned sample jars for the various chemical or biological analyses. For toxicity testing, fill sample jars to the top with sediment to minimize available headspace. This procedure will minimize any oxidation reactions within the sediment. For chemical analysis, sample containers may be frozen for storage. Leave enough headspace to allow for sediment expansion.

After dispensing the sediment, place the containers into coolers with ice and either ship them directly to the analytical laboratories or transport them to a storage facility.

REFERENCES

ASTM. 2003. *Standard Practice for Collecting Benthic Macroinvertebrates with Ekman Grab Sampler*. ASTM Standards on Disc, Volume 11.05.

USEPA. 1996. Puget Sound Estuary Program: Recommended protocols for measuring selected environmental variables in Puget Sound. Prepared for U.S. Environmental Protection Agency, Region 10, and Puget Sound Estuary Program, Seattle, WA. Tetra Tech and HRA, Inc., Bellevue, WA.

STANDARD OPERATING PROCEDURE (SOP) SD-06

HOLLOW-STEM AUGER DRILLING/SEDIMENT SAMPLING

SCOPE AND APPLICATION

Soil/sediment cores are collected to evaluate sediment at depths that greatly exceed those achieved by grab or other surface samplers. The purpose of this standard operating procedure (SOP) is to define and standardize procedures for core collection using split-spoon and Shelby tube samplers advanced through hollow-stem auger borings, following American Society for Testing and Materials (ASTM) Method D1586 and Method D1587, respectively. The use of Shelby tube samplers or split-spoon samplers is specified in the Slip 4 Pre-Design Sampling and Analysis Plan Addendum (Integral 2006). Shelby tubes will be used to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties such as strength, compressibility, permeability, and density.

REQUIRED EQUIPMENT

- Sampling and Analysis Plan (SAP).
- Health and Safety Plan (HSP).
- Site logbook and boring log.
- Indelible black-ink pens and markers.
- Camera.
- Hollow-stem auger drill rig.
- Driller and helper.
- Split-spoon samplers (typically 2-in. diameter; a larger 3-in. diameter, 2-ft-length split-spoon may be used to obtain more material from each depth interval).
- Shelby tube samplers conforming to thin-walled tube specifications outlined in ASTM D1587 with a 2- to 5-in. O.D and 5 to 10 times the diameter in length. Wax and end caps will also be provided for proper field sealing.
- Photoionization detector (PID).
- Plastic sheeting.
- 55-gallon drums (if required).
- Insulated cooler(s), chain-of-custody seals, Ziploc® bags.
- Sample labels and appropriate documentation.

- Assorted geology supplies (e.g., hand lens, grain-size card, scales, etc.).
- Decontamination equipment (SOP-10).

Typical Procedures

1. Ensure underground utilities in vicinity of each boring location have been marked prior to mobilizing drill rig to site.
2. Conduct daily site activity/health and safety briefing.
3. Calibrate field instrumentation, if applicable.
4. Record necessary data in field logbook.
5. Obtain photograph(s) of site before drilling.
6. Place plastic sheeting and/or drums at drilling location to collect cuttings (if necessary).
7. Move equipment and supplies to drilling location.
8. Set up decontamination and sampling stations.

Split-Spoon Sampling

1. Obtain surface soil samples, if required.
2. Drill to first sampling depth, as described in the SAP.
3. Place decontaminated split-spoon sampler on center rods.
4. Drive split-spoon sampler, as described in ASTM Method D-1586. Drive sampler to 18 inch or to refusal (no progress for 50 blows). Record blow counts on boring log form. Retrieve sampler.
5. Screen sampler with PID (if required).
6. Describe soil in accordance with ASTM D2488 on the boring log form.
7. Composite soil sample, as necessary. If volatile organic compound (VOC) samples are to be collected, collect VOC sample prior to describing soil.
8. Continue drilling at next sample location. Collect samples as outlined above.
9. Label and manage sample containers in accordance with the site-specific SAP section for shipping and handling of samples.
10. Decontaminate sampling equipment in accordance with the site-specific SAP.
11. Document activities in site logbook.
12. Backfill or grout borehole, as required.

13. Move to next location.

Shelby Tube Sampling

1. Obtain surface soil samples, if required.
2. Drill to first sampling depth, as described in the SAP.
3. Place decontaminated Shelby tube sampler on center rods.
4. Drive Shelby tube sampler, as described in ASTM Method D1587. Retrieve the sampling tube and remove the disturbed material from the top of the tube. In addition, remove 1 inch of soil from the base of the tube. Place an impervious disk at both ends of the tube seal with a wax plug prior to shipment to the laboratory.
5. If Shelby tubes are to be extruded in the field for composite sampling, the driller will use a hydraulic extruder to obtain the sample. The core is then described in accordance with ASTM Method D2488 on the boring log form. Samples will then be composited, as necessary, for analysis.
6. Screen sampler with PID (if required).
7. Label and manage sample containers in accordance with the site-specific SAP section for shipping and handling of samples. The sample tube should be packed in Styrofoam™ plugs or other cushioning material to prevent disturbance of the sample.
8. Continue drilling to next sample location. Collect samples as outlined above.
9. Decontaminate sampling equipment in accordance with the site-specific SAP section.
10. Document activities in site logbook.
11. Backfill or grout borehole, as required.
12. Move to next location.

Reference

Integral. 2006. Lower Duwamish Waterway Slip 4 Early Action Area: Sampling and Analysis Plan for Boundary Definition Addendum: Pre-Design Investigation Sampling. Prepared for Seattle City Light and King County, Seattle, WA. Integral Consulting Inc., Mercer Island, WA.

STANDARD OPERATING PROCEDURE (SOP) SD-08

SUBSURFACE SEDIMENT CORE COLLECTION

SCOPE AND APPLICATION

This SOP outlines the procedure for collecting core samples from target locations using a vibracorer equipped with a Lexan®-lined dedicated core tube. The vibracorer offers a high rate of production, superior retention of shallow samples, and a greater sample volume compared to conventional drilling equipment. The vibracorer also provides greater penetration capabilities than piston-type or conventional gravity corers when encountering compact subsurface sediments.

SUMMARY OF METHOD

Undisturbed, continuous sediment cores will be collected using a vibracore system. The vibracore system utilizes a high-frequency vibrating head to break down the frictional resistance of the sediment and allow the core tube to penetrate into the sediment with minimal distortion. This method is well suited for collecting continuous, undisturbed cores from soft sediment types.

The vibracorer uses a hydraulic system that vibrates and drives a 4-in.-outside-diameter, aluminum core tube with location-dedicated Lexan® liner into the sediment. A continuous sediment sample is retained within the tubing with the aid of a stainless-steel core cutter/catcher attached to the bottom of each aluminum tube.

Following positioning at a given sampling station, the vibracorer is deployed off the foredeck of the vessel and slowly lowered to the sediment surface. Vibracoring continues until adequate core penetration (sample depth) is achieved.

After collection of the core sample, the vibracorer is slowly raised to the deck of the vessel. Before the Lexan® core tube is removed from the vibracorer, the core cutter/catcher is visually inspected to ensure that proper penetration has been attained and that there is no obvious loss of sediment from the tube. Any presence of noticeable odors or sheen at the end of the tube or in the water will also be noted.

The core penetration depth and physical characteristics (e.g., color, texture, odor) of the sediment sample as observed at the ends of the tube will be recorded in the field logbook by an experience geologist.

Cores are cut into manageable sections (3–4 ft) aboard the vessel immediately after their retrieval. They are then capped with aluminum foil and plastic caps, and sealed with duct tape. Following sectioning, the cores are stored onboard the vessel in a core box and transported periodically throughout each field day by small boat to a field-based laboratory where they are stored upright on ice or refrigerated at 4°C to await processing.

PROCEDURES

Vibracorer Deployment and Retrieval

The procedures for vibracorer deployment and retrieval are as follows.

- Maneuver the sampling vessel to the targeted sampling location using the positioning procedures and minimum water depth restrictions.
- Deploy 3- or 4-point anchor system to maintain position; record and monitor position throughout core acquisition.
- Assemble the decontaminated core tube, liner, catcher, and cutterheads using care to not contact decontaminated surfaces. Attach assembled vibracorer to winch cable. Note that several decontaminated catchers and cutterheads will be on hand, in case of loss. These items can be reused for subsequent core collection.
- Attach a tape measure to the vibracorer or mark the winch cable in 1/2-ft increments to measure penetration depth.
- Signal the winch operator to lift the vibracorer.
- Guide the vibracorer (with core liner, valve, core catcher, and cutterhead in place) overboard until it is clear of the vessel.
- Lower the vibracorer through the water column slowly to avoid creating a bow wake or overturning of the instrument. Lower until the tip of the core is resting on the sediment or to the depth recorded by the fathometer, depending on the consistency of the sediment. Record the vibracorer depth as derived from the attached tape measure or marked winch cable. Measurements will serve as a basis for determining penetration depth.
- Turn on the vibracorer and lower to the target penetration distance as measured by the attached tape measure or marked winch cable. If the targeted penetration depth is met, proceed to the next step; if refusal is met, retrieve the vibracorer, perform gross decontamination (i.e., rinse with river water and brush off visible sediment) and re-attempt at new location offset at least 3–5 ft from original location.
- Turn off the vibracorer and record the time, penetration distance, angle of the cable relative to the boat, and any other observations.

- Signal the winch operator to begin retrieving the corer and raise it slowly at a constant rate to keep the instrument upright and not dislodge any sediment from within the core barrel.
- Guide the vibracorer onboard the vessel and place it on the work vessel deck; use care to avoid jostling that might disturb the integrity of the core. Care must be taken to keep the top end of core elevated to prevent sediment from “pouring” out. Use a sawhorse or equivalent to elevate the top of the core.
- Unscrew the core cutter and carefully remove the core catcher, while retaining as much sediment as possible.
- Affix core cap, wrap with tape, and label core liner and end of core.
- Remove liner from core barrel, lifting lower end from the deck as needed to provide clearance. Remove valve from top of core liner, stand upright, and allow sediment at top to settle.
- While waiting for sediment to settle, prepare core log. Identify any debris as to depth in core and what the debris is, if possible.
- Once resuspended sediment has settled, use a decontaminated saw to cut a drain-slit or a decontaminated drill bit to drill in the side of the core liner approximately 1 to 2 in. above the sediment–water interface; allow excess water to drain. Cut excess polycarbonate liner with decontaminated blade.
- In preparation for next core, thoroughly rinse the interior of the core barrel until all loose sediment has been washed off.

Repeat process at next sampling location. Continue coring until requirements are met.

In situations where there is significant surface water depth and/or water current that could cause the vibracorer setup to lean at an unacceptable angle, a buoyant frame or rigid frame configuration should be used.

With the buoyant frame, the vibracorer is maintained in proper vertical position by two guidelines held taut between a float package and a weight stand. The larger weight stand is provided with ballast boxes so that easy-to-find ballasting material such as lead bags or scrap metal can be used in the field. For deployment, the vibracorer is lowered with the weight stand hanging on its guidelines from the vibrahead. The float package is hooked up to the guidelines when the vibrahead reaches the deck level.

After coring and pull-up, the system is retrieved in the reverse manner. In case of limited deck space or overhead clearance, or to further accelerate the procedure on the water, the weight stand can be left in as overboard cradle.

Sample Handling and Storage

Cores should be processed concurrently with core collection, and every effort should be made to ensure cores are processed within 24 hours of collection. Cores awaiting processing will be sealed tightly at both ends and stored upright in a refrigerator. If core collection outpaces processing such that significant delays in core processing appear likely, core collection will be suspended to allow the core processing to catch up.

The field laboratory will be equipped with a core-cutting table, core-processing tables, a decontamination area, and a storage area with appropriate refrigeration. Appropriate lighting will be installed in the core processing area so that consistent, high quality photographs can be taken of the opened cores. Care should be taken to create a core-processing area that minimizes the potential for outside contamination.

- Cut each core tube along the long axis using decontaminated hook blade. Rotate the tube 180° and cut again.
- After each core is cut, move the entire core tube to an aluminum foil covered table and open it so that it can be systematically logged, described, and photographed.
- After each core is cut open, describe the sediment on a core log in the field laboratory notebook. When recording the information for each core, follow the guidelines below:
 - Physical sediment description (i.e., sediment type, density/consistency, color)
 - Odor (e.g., hydrogen sulfide, petroleum)
 - Visual stratification and lenses
 - Vegetation
 - Debris
 - Evidence of biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
 - Presence of oil sheen
 - Other distinguishing characteristics or features.

The visual observations of sediment lithology (dominant grain sizes) will be the primary criteria for determining sample intervals (i.e., lithologic units) in the cores. For consistency, core descriptions and terms used will follow the criteria below, which are modified from methods presented in ASTM D 2488-00 (ASTM 2000).

- Record visual estimates of the grain-size percentages of sediment units within each core on the core logs so that the total sum will add up to 100 percent. Make estimates of gravel, sand, and fines (silt and clay) content generally to the nearest quartiles:

- 0 to 25 percent
- >25 to 50 percent
- >50 to 75 percent
- >75 to 100 percent.

If appropriate, describe the sediment narratively on the log based on the estimated grain-size percentages. Use the dominant constituent grain size as the primary unit descriptor, and describe the abundance of other grain sizes present using the following terms:

- The grain-size adjective (e.g., gravelly, sandy, silty, or clayey), if estimated to constitute more than 25 percent of the sediment
- *With*, for example, sand with silt, silt with sand, etc., if estimated to constitute less than 25 percent of the sediment
- *Trace*, if estimated at less than 5 percent of the sediment (and not included in the total 100 percent).

For other features observed, such as organics or debris, use the following additional descriptive terms as appropriate:

- *Mostly*, if estimated to constitute 50 percent or more of the unit
- *Some*, if estimated to constitute more than 25 to 50 percent of the unit
- *Little*, if estimated to be 25 percent of the unit or less
- *Trace*, if estimated at less than 5 percent (and not included in the total 100 percent).
- Describe density using the following terms:
 - *Loose*, if easily penetrated with a sampling spoon
 - *Dense*, if penetration is more difficult.
- Describe consistency using the following terms:
 - *Very soft*, if present as an ooze that holds no shape
 - *Soft*, if saggy
 - *Stiff*, if it holds a shape
 - *Very stiff*, if penetration with a spoon is low
 - *Hard*, if no penetration with a spoon is possible.
- Use other observations (e.g., obvious anthropogenic material, dramatic color changes) to define or help define sample intervals.

- Determine the boundaries of lithologic units primarily by changes in the top two dominant grain sizes estimated visually (e.g., a change from a silty sand to a gravelly sand or to a sandy silt).
- Photograph the cores after being described and before any sediment is removed for processing. It is important for each core section to be photographed with adequate lighting from a standard measured distance from the core. Digital photographs will be used later in the production of digital core logs.
- Place subsampled sediment into a decontaminated stainless-steel bowl. Collect adequate volumes of sediment for all required analyses.
- Mix sediment from each subsample individually in the decontaminated, stainless-steel bowl to a uniform color and texture using a decontaminated, stainless-steel spoon. Stir the sediment periodically while individual samples are taken to ensure that the mixture remains homogeneous. Exercise care to not include sediment that is in direct contact with the core tube. Fill pre-labeled jars for chemical testing with the homogenized sediment.

The types and number of field quality control samples for subsurface sediment samples will follow the same guidelines prescribed for surface sediment samples. If additional volumes of sediment are required to perform all analyses in addition to quality control analyses, an additional core may need to be collected from the same location and subsampled and homogenized accordingly.

When required, sediment subsamples to be analyzed for volatile organic compounds will be collected from within appropriate intervals following the opening of the core and designation of the lithologic units. This process will minimize the release of volatile organic compounds caused by mixing.

Sediment handling equipment that comes in direct contact with the sample, such as scoops, spoons, and mixing bowls that are not dedicated to an individual sample, will be decontaminated in accordance with SOP SD-01 prior to use at each station and between field replicates.

REFERENCES

ASTM. 2000. Standard practice for description and identification of soils (visual-manual procedure). ASTM Standard Method No. D 2488-00. In: ASTM Book of Standards, Volume 04.08. American Society for Testing and Materials, West Conshohocken, PA.

STANDARD OPERATING PROCEDURE (SOP) SD-12

LOGGING OF SEDIMENT CORES

SCOPE AND APPLICATION

The following procedures for completing the Field Sediment Core Form establish the minimum information that must be recorded in the field to adequately document sediment coring activities. The field sediment core form must be filled out completely. Depending upon project specific requirements, some of the items listed below can be recorded in the observing scientist's field logbook and/or on the Station Core Log. All field forms must be filled out completely.

All of the information addressed in this standard operating procedure (SOP) should be included in the observing scientist's field documentation. Additionally, standards presented may need to be supplemented with additional technical descriptions or field test results (see project specific field sampling plan [FSP]).

ACTIVITIES OF THE OBSERVING SCIENTIST DURING CORING

1. Record the name of the coring contractor and personnel performing the coring (lead person and any support staff)
2. Record the type and make of the coring equipment being used
3. Note the weather or any special external conditions that influence the coring
4. Be certain that the coring contractor is informed about the nature of the daily records that the contractor will keep
5. Check the coring contractor's daily records to verify their accuracy
6. Note date and time of all activities associated with the coring
7. Make certain that the coring contractor follows all required procedures
8. The observing scientist's daily record shall include, but may not be limited to, the following items:
 - Date and depth of core
 - Depth of start and finish of each sampled interval
 - Depth and size of any casing or core tubing used
 - Time required to advance the core
 - Loss of water, mud, or air during sample retrieval

- Depth of overlying water
- Simplified description of strata
- Total sample recovery (in inches or centimeters)
- Details of delays and breakdowns.

The observing scientist should also record the coring start and finish dates and times. For consecutive sheets, provide, at a minimum, the project number, the station number, and the sheet number. This list excludes any special items that may be required for contractual record purposes or for special tests (see project-specific FSP).

Data on Field Sediment Core Form

Core Type/Method: Provide the sampler type (e.g., GC = gravity corer, PC = piston corer, DRCV = drive rod check valve corer, VC = vibracorer, BC = box corer).

Sample Number/Tag Number: Provide the sample number. The sample numbering scheme should be established before sampling begins. Consult the project-specific FSP for the sample numbering scheme. The depth of the sample is the depth to the top of the recovered sample to the nearest centimeter. Samples should be obtained from the entire recovered core (depending upon the sampling intervals specified in the project-specific FSP). The tag number(s) and respective sample number(s) of the sample container(s) should also be recorded in the field logbook.

Photograph Number: Provide the number of the film roll and the photograph number.

Odor: Provide information on presence of any odor associated with the sediment. Document each interval in the core at which an odor is present. Describe the odor in the *Sediment Description* section of the field sediment core form.

Sheen: Provide information on presence of any sheen associated with the sediment. Document each interval in the core at which sheen is present. Also note if sheen is present on the water surface during coring activities.

Blank Columns: Two blank columns are provided on the field sediment core form. These columns can be used for site-specific information, usually related to the contaminants of concern (e.g., sheen, air quality measurements).

Water Breaks: Record the location of any observed breaks in the sediment core.

Depth Scale: Enter the depth of the core below sediment surface. Match the sediment descriptions with the depth scale.

Unified Symbol: If a geologist is providing the sediment descriptions of the core, then the unified symbol code (USC) for different sediment types (e.g., silt, clay, sand) should be placed in this column. The USC name should be identical to the ASTM D-2488-84 Group Name with the appropriate modifiers.

Table SD-12(1) presents the USC classification system. The USC system is an engineering properties system that uses grain size to classify soils, it can however also be used by a geologist to characterize the sediment in a core.

Table SD-12(1). USC Classification System

Major Divisions			Group Symbol	Group Name
Coarse-grained soils More than 50 percent retained by No. 200 sieve	Gravel More than 50 percent of coarse fraction retained on No. 4 sieve	Clean Gravel	GW	Well-graded gravel, fine to coarse gravel
			GP	Poorly graded gravel
		Gravel with fines	GM	Silty gravel
			GC	Clayey gravel
	Sand More than 50 percent of coarse fraction passes No. 4 sieve	Clean Sand	SW	Well-graded sand, fine to coarse sand
			SP	Poorly graded sand
		Sand with fines	SM	Silty sand
			SC	Clayey sand
Fine-grained soils More than 50 percent passes No. 200 sieve	Silt and clay Liquid limit < 50	Inorganic	ML	Silt
			CL	Clay
		Organic	OL	Organic silt, organic clay
	Silt and clay Liquid limit ≥ 50	Inorganic	MH	Silt of high plasticity, elastic silt
			CH	Clay of high plasticity, fat clay
		Organic	OH	Organic clay, organic silt
Highly organic soils			PT	Peat

Note: Field classification is based on visual examination of soil in general accordance with ASTM D-2488-84.

Soil classification using laboratory tests is based on ASTM D-2487-83.

Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

Liquid limit is the water content of soil-water where the consistency changed from plastic to liquid.

Sediment Description: The sediment description should follow the format described in SOP SD-13, *Field Classification of Sediment*. Information on sediment should include sediment type, percent moisture with depth through the core, color, and presence or absence of vegetation or biota. The surface conditions within the core (i.e., overlying water is present, undisturbed sediment/water interface, presence of any vegetation or biota) should also be described. The project-specific FSP should be consulted for any special descriptive items that may be required.

Comments: Include all pertinent observations. Coring observations might include coring chatter, core-bounce (hard object hit by corer during penetration), sudden differences in

coring speed, damaged coring equipment, and malfunctioning equipment. Information provided by the coring contractor should be attributed to the coring contractor.

Data on Station Core Log

Cast Number: Record the number of coring attempts at each station.

Start/End Time: The time should be recorded during coring to determine coring speed. Time should be recorded in 24- hour mode (e.g., 3:00 p.m. = 1500 hours).

Water Depth: Record the overlying water depth at the station. Note: The overlying water depth can change between coring attempts and therefore must be measured prior to each attempt.

Core Penetration Depth: Record the depth that the core was pushed into the sediment. Note: If this information is not readily apparent, it can be obtained from the coring contractor.

Retrieved Core Length: While the sediment core is vertical, record the length of the retrieved core.

Overlying Water: Record whether or not there is water on top of the sediment core once the core has been retrieved. This is necessary to determine measurable sediment/water interface.

Coordinates: Record the latitude and longitude (or geographic) of the station location. The datum used to collect the station location coordinates (e.g., WGS84) must also be recorded in the field notes.

STANDARD OPERATING PROCEDURE (SOP) SD-13

FIELD CLASSIFICATION OF SEDIMENT

SCOPE AND APPLICATION

This SOP presents the field classification of sediments to be used by Integral field staff. Sediment descriptions should be precise and comprehensive without being verbose. Assumptions and personal comments should not be included in the sediment descriptions. These descriptions will be used to interpret environmental conditions and other potential properties, rather than the exact mineralogy or tectonic environment.

Sediment descriptions should be recorded in either the observing scientist's field logbook, or if subsurface sediment is collected, then the sediment description column of the Field Sediment Core Form should be completed for each core collected. If no difference between consecutive sediment samples exists, subsequent descriptions can be noted as "same as above," or minor changes such as "increasing sand" or "becomes dark brown" can be added.

After the overlying water is removed, characterize the sediment. Sediment characteristics that are often recorded in the field logbook or the Field Sediment Core Form if subsurface sediment is collected, include:

- Sediment type (e.g., silt, sand)
- Texture (e.g., fine grain, coarse, poorly sorted sand)
- Color
- Presence/location/thickness of the redox potential discontinuity layer (a visual indication of black is often adequate for documenting anoxia)
- Approximate percentage of moisture
- Presence of biological structures (e.g., chironomids, tubes, macrophytes) and the approximate percentage of these structures
- Presence of organic debris (e.g., twigs, leaves) and the approximate percentage of debris
- Presence of shells and the approximate percentage of shells
- Stratification, if any
- Presence of a sheen
- Odor (e.g., hydrogen sulfide, oil, creosote).

In addition, the project-specific field sampling plan should be reviewed to determine if there are any project-specific reporting requirements.

In general, the similarities of consecutive sediment samples should be noted. Examples of surface sediment descriptions are provided in Table SD-13(1). The minimum elements of the sediment descriptions are discussed below. The format of sediment descriptions for each sample should be consistent throughout the logbook.

Table SD-13(1). Example of Surface Sediment Descriptions

Station No.	Grab No.	Example Descriptions
TC01	1	SILT, mottled dark gray (10YR 4/1) with thin layer < 1 cm of very pale brown (10YR 7/4) on surface. Occasional roots, some twigs, and leaves on surface. Slight reducing odor. Sheen on overlying water in grab.
TC02	1	Sandy SILT, fine sand, dark gray (10YR 4/1) throughout grab, with 10 percent medium to coarse sand, trace woody debris. Chironomid on surface.
TC02	2	Same description as first grab at Station TC02.
TC02	3	Same description as first grab at Station TC02, but no sand (SILT only) and color is very dark gray (10YR 3/1) with no chironomid present.

Definition of Sediment Types

Fine-grained sediments are classified as either silts or clays. Field determinations of silts and clays are based on observations of dry strength, dilatancy, toughness, and plasticity. Field procedures for these tests are included in ASTM D-2488-84. If these tests are used, the results should be included in the sediment description. Sediments with high plasticity can be emphasized by describing them as “silty CLAY with high plasticity.” Plasticity is an important descriptor because a sediment can be dilatant/nonplastic and serve as a transport pathway, or it can be highly plastic and very impervious.

Coarse-grained sediments are classified as predominantly sand. The gradation of a coarse grained sediment is included in the specific sediment name (i.e., fine to medium SAND with silt). Estimating the percentage of size ranges following the group name is encouraged for mixtures of silty sand and sand. If applicable, use the modifiers “poorly graded” or “well graded” when describing the sand component of the sediment.

Color

The basic color of a sediment, such as brown or gray, must be provided in the description. The color term can be modified by adjectives such as light, dark, or very dark. Especially

note streaking or mottling. The color chart designations provided in either the *Globe Soil Color Book* or the Munsell color guide can be used.

Moisture Content

The degree of moisture present in the sediment should be defined as moist, wet, or very wet. The percent moisture content should be estimated.

Other Components

Other components, such as organic debris and shell fragments, should be preceded by the appropriate adjective reflecting relative percentages: trace (0–5 percent), few (5–10 percent), little (15–25 percent), and some (30–45 percent). The word “occasional” can be applied to random particles of a larger size than the general sediment matrix (i.e., occasional stone, large piece of wood).

Additional Descriptions

Features such as sloped surface in the grab, root holes, odor, and sheen should be noted if they are observed. Anything unusual should be noted. Additional sediment descriptions may be made at the discretion of the project manager or as the field conditions warrant.

STANDARD OPERATING PROCEDURE (SOP) SL-05

SURFACE SOIL SAMPLING

SCOPE AND APPLICATION

This SOP defines and standardizes the collection of surface soil samples (e.g., 0 to 12 in. below ground surface). Soil samples should be collected from areas having lower levels of constituents of interest first, followed by stations with higher expected levels of constituents of interest.

The procedures listed below may be modified in the field upon the agreement of the lead site sampler and field personnel, based on field and site conditions, after appropriate annotations have been made in the field logbook. If specialized sampling methods (e.g., ENCORE®) are to be used, refer to the manufacturer's recommended procedures. If methanol preservation is required, refer to Integral's SOP on methanol preservation of soil samples. Record all pertinent information on Integral's surface soil sampling field data form or field logbook.

EQUIPMENT AND SUPPLIES REQUIRED

- Decontaminated sampling tool (stainless-steel shovel, scoop, trowel, or spoon)
- Large stainless steel mixing bowl and spoon
- Laboratory-supplied sample containers, insulated coolers, and ice
- Chain-of-custody forms, custody seals, sample labels
- Ziploc® bags
- Camera
- Tape measure
- Field logbook, surface soil field collection form, and pens
- Project-specific field sampling plan (FSP) and health and safety plan (HSP)
- Personal protective equipment (safety glasses, steel-toed boots, nitrile gloves, and any other items required by the project-specific HSP)
- Decontamination equipment.

PROCEDURES

1. Locate the sample station as directed in the project-specific FSP. Label containers with sample tags prior to filling in accordance with Integral's SOP on sample labeling (SOP-AP04). If analytical testing will be performed for volatile organic compounds (VOCs), collect the VOC sample first (with a minimum of disturbance) by placing the sample into the container with a minimum amount of headspace and sealed tightly.
2. Don a new pair of nitrile gloves and expose the soil surface by clearing an approximately 1 ft² area at the sampling site of any rocks or organic material greater than approximately 3 in. in size. Note any material removed from the sampling site in the field logbook.
3. Using a decontaminated stainless-steel sampling tool, excavate soil to the depth specified in the work plan.
4. If required for analysis, first collect VOC samples (prior to any homogenization) from a discrete location, placing the samples in the appropriate containers. Label sample containers before filling in accordance with Integral's SOP on sample labeling (SOP AP-04).
5. Place additional sample material in a decontaminated plastic or stainless-steel mixing bowl.
6. Describe the soil in accordance with ASTM D2488-00 (see Integral's SOP on field classification of soils, SOP SL-04).
7. Thoroughly mix and homogenize the sample using disposable equipment or a decontaminated stainless-steel spoon until the color and texture are consistent throughout.
8. If required for analysis, first collect samples for grain-size tests before any large rocks are removed from the homogenized soil.
9. Identify any rocks that are greater than 0.5 in. in diameter. Determine their percentage contribution to the homogenized soil volume, note it on the surface soil field collection form or in the field logbook, and then discard the rocks.
10. Remove samples of the homogenized soil from the mixing bowl with the decontaminated stainless steel spoon and place in the appropriate size sample container. Do not touch the sample with your gloves. Fill the sample container with soil to just below the container lip, and seal the container tightly. Label sample containers before filling in accordance with Integral's SOP on sample labeling.
11. Mark the sampling site with a wire flag, wooden stake, metal rebar, or flagging, as appropriate.

12. Complete all pertinent field QA/QC documentation, logbooks, sample labels, and field data sheets. Record any deviations from the specified sampling procedures or any obstacles encountered.
13. Photograph sample location and document it in the logbook.
14. Decontaminate all sampling equipment according to Integral's SOP on decontaminating equipment for soil sampling (SOP SL-01) and in accordance with the project-specific FSP.

STANDARD OPERATING PROCEDURE (SOP) SL-06

LOGGING OF SOIL BOREHOLES

SCOPE AND APPLICATION

This SOP describes how to complete a Soil Boring Log form, which must be completed for Integral projects where soil boring techniques are performed during field exploration. A correctly completed form contains all of the information that must be recorded in the field to adequately characterize soil boreholes.

These procedures are adapted from ASTM D-2488-00. Field staff are encouraged to examine ASTM D-2488-00 in its entirety. This SOP represents minor modifications to emphasize environmental investigations rather than geotechnical investigations, for which the standards were written. Because each environmental project is unique and because job requirements can vary widely, the minimum standards presented may need to be supplemented with additional technical descriptions or field test results. However, all soil boring field logs, regardless of special project circumstances, must include information addressed in this SOP to achieve the minimum acceptable standards required by Integral.

LOG FORM INFORMATION

Project Number—Use the standard contract number.

Client—Identify the name of the client and the project site location.

Location—If stations, coordinates, mileposts, or similar markers are applicable, use them to identify the location of the project. If this information is not available, identify the facility (e.g., 20 ft NE of Retort #1).

Drilling Method—Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, cable tool) and the name of the drill rig (e.g., Mobil B 61, CME 55).

Diameter—Provide the diameter of the borehole. If the borehole has variable diameters, provide the depth interval for each diameter.

Sampling Method—Identify the type of sampler(s) used (e.g., standard split spoon, Dames & Moore sampler, grab).

Drilling Contractor—Provide the name of the drilling contractor.

Integral Staff—Enter the name(s) of Integral staff members performing logging and sampling activities.

Water Level Information—Provide the date, time, depth to static water, and casing depth. Generally, water levels should be taken each day before resuming drilling and at the completion of drilling. If water is not encountered in the boring, this information should be recorded.

Boring Number—Provide the boring number. A numbering system should be developed prior to drilling that does not conflict with other site information, such as previous drilling or other sampling activities.

Sheet—Number the sheets consecutively for each boring and continue the consecutive depth numbering.

Drilling Start and Finish—Provide the drilling start and finish dates and times.

For consecutive sheets, provide (at a minimum) the job number, boring number, and sheet number.

TECHNICAL DATA

Sampler Type—Provide the sampler type (e.g., SS = split spoon, G = grab).

Depth of Casing—Enter the depth of the casing below ground surface immediately prior to sampling.

Driven/Recovery—Provide the length that the sampler was driven and the length of sample recovered in the sampler. This column would not apply to grab samples.

Sample Number/Sample Depth—Provide the sample number. The sample numbering scheme should be established prior to drilling. One method is to use the boring number and consecutive alphabetical letters. For instance, the first sample obtained from boring MW-4 would be identified as 4A, the second would be identified as 4B, and so on. Another method for sample identification is naming the boring number with the depth. For example, the sample from Boring 1 at 10 ft would be labeled B1-10'. The depth of the sample is the depth of the casing plus the length to the middle of the recovered sample to the nearest 0.1 ft. Typically, split spoon samplers are 18 in. long. Samples should be obtained from the middle of the recovered sample. The depth of the sample with the casing at 10 ft would then be 10.7 ft.

Number of Blows—For standard split-spoon samplers, record the number of blows for each 6 in. of sampler penetration. A typical blow count of 6, 12, and 14 is recorded as 6/12/14. Refusal is a penetration of less than 6 in. with a blow count of 50. A partial penetration of 50 blows for 4 in. is recorded as 50/4". Total blows will be recorded for nonstandard split spoons (e.g., 5-ft tube used for continuous sampling).

Blank Columns—Two blank columns are provided. Use these columns for site-specific information, usually related to the chemicals of concern. Examples for a hydrocarbon site would be sheen and photoionization detector readings of the samples.

Depth—Use a depth scale that is appropriate for the complexity of the subsurface conditions. The boxes located to the right of the scale should be used to graphically indicate sample locations as shown in the example.

Surface Conditions—Describe the surface conditions (e.g., paved, 4-in. concrete slab, grass, natural vegetation and surface soil, oil-stained gravel).

Soil Description—Enter the soil classification and definition of soil contacts using the format described in SOP SL-04, *Field Classification of Soil*.

Comments—Include all pertinent observations. Drilling observations might include drilling chatter, rod-bounce (boulder), sudden differences in drilling speed, damaged samplers, and malfunctioning equipment. Information provided by the driller should be attributed to the driller. Information on possible contaminants might include odor, staining, color, and presence or absence of some indicator of contamination. Describe what it is that indicates contamination (e.g., fuel-like odor, oily sheen in drill cuttings, yellow water in drill cuttings).

ATTACHMENT 1. SOIL BORING LOG FORM



319 SW Washington St., Suite 1150
Portland, OR 97204
(503) 284-5545

STATION NUMBER _____
PROJECT _____
LOCATION _____
PROJECT NUMBER _____
LOGGED BY _____

Page 1 of ____

SAMPLE INFORMATION						STRATA	DESCRIPTION
Sample ID	Depth	Time	Tag No.	% Recov.	Depth (Feet)		USCS group name, color, grain size range, minor constituents, plasticity, odor, sheen, moisture content, texture, weathering, cementation, geologic interpretation, etc.
					2--		
					4--		
					6--		
					8--		
					10--		
					12--		
					14--		

DRILLING CONTRACTOR _____
DRILLING METHOD _____
SAMPLING EQUIPMENT _____
DRILLING STARTED _____
COORDINATES _____
SURFACE ELEVATION _____
DATUM _____

Location Sketch

**ATTACHMENT 2. ASTM D 2488 – 00, STANDARD PRACTICE FOR
DESCRIPTION AND IDENTIFICATION OF SOILS (VISUAL-MANUAL
PROCEDURE)**



Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)¹

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements see Section 8.*

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not*

intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 ASTM Standards:

D 653 Terminology Relating to Soil, Rock, and Contained Fluids²

D 1452 Practice for Soil Investigation and Sampling by Auger Borings²

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils²

D 1587 Practice for Thin-Walled Tube Sampling of Soils²

D 2113 Practice for Diamond Core Drilling for Site Investigation²

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)²

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction³

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)²

3. Terminology

3.1 **Definitions**—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 **clay**—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the

¹ This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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² Annual Book of ASTM Standards, Vol 04.08.

³ Annual Book of ASTM Standards, Vol 04.09.



fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the “A” line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the “A” line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid

limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

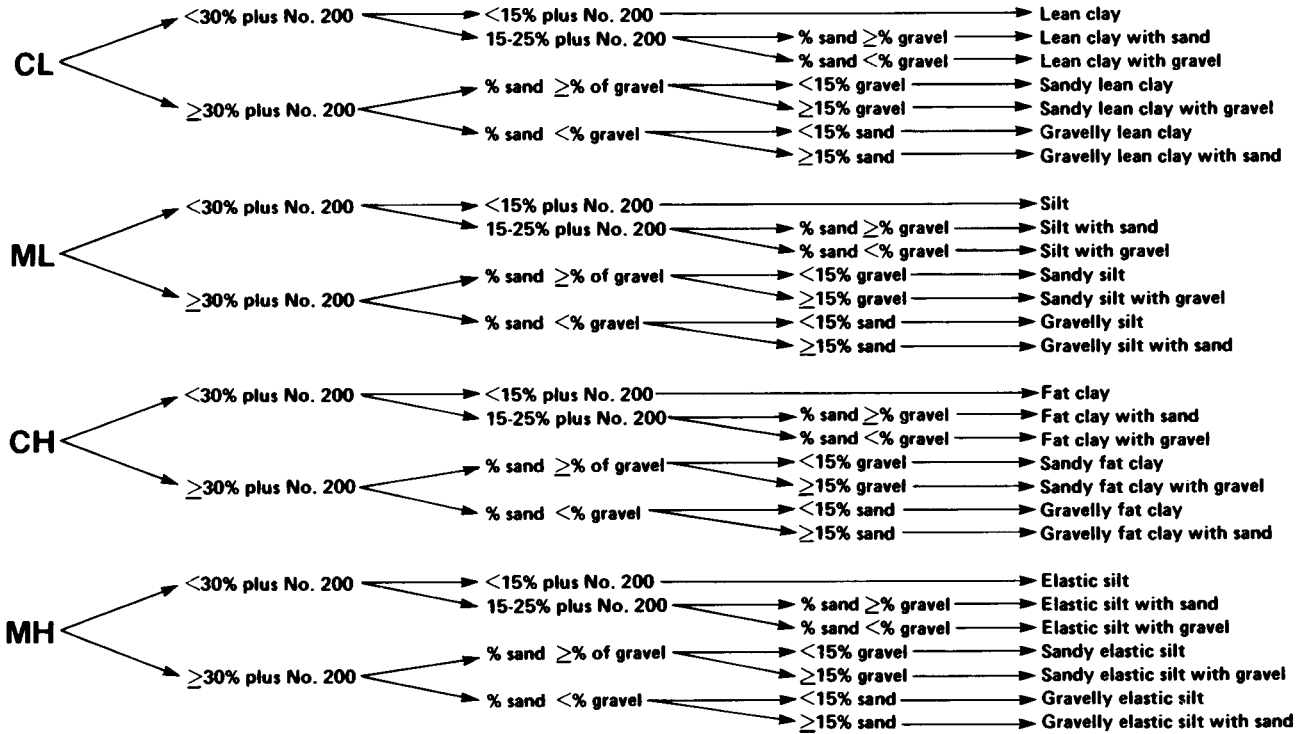
6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references

GROUP SYMBOL

GROUP NAME

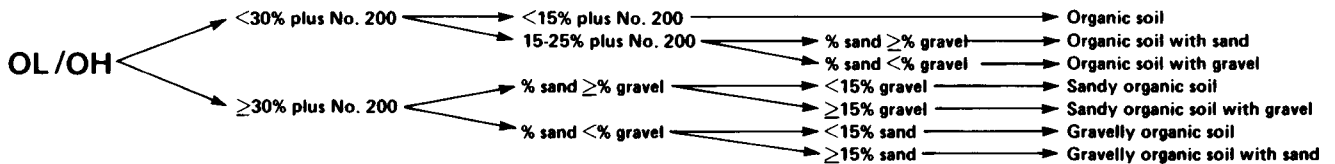


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

GROUP SYMBOL

GROUP NAME



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

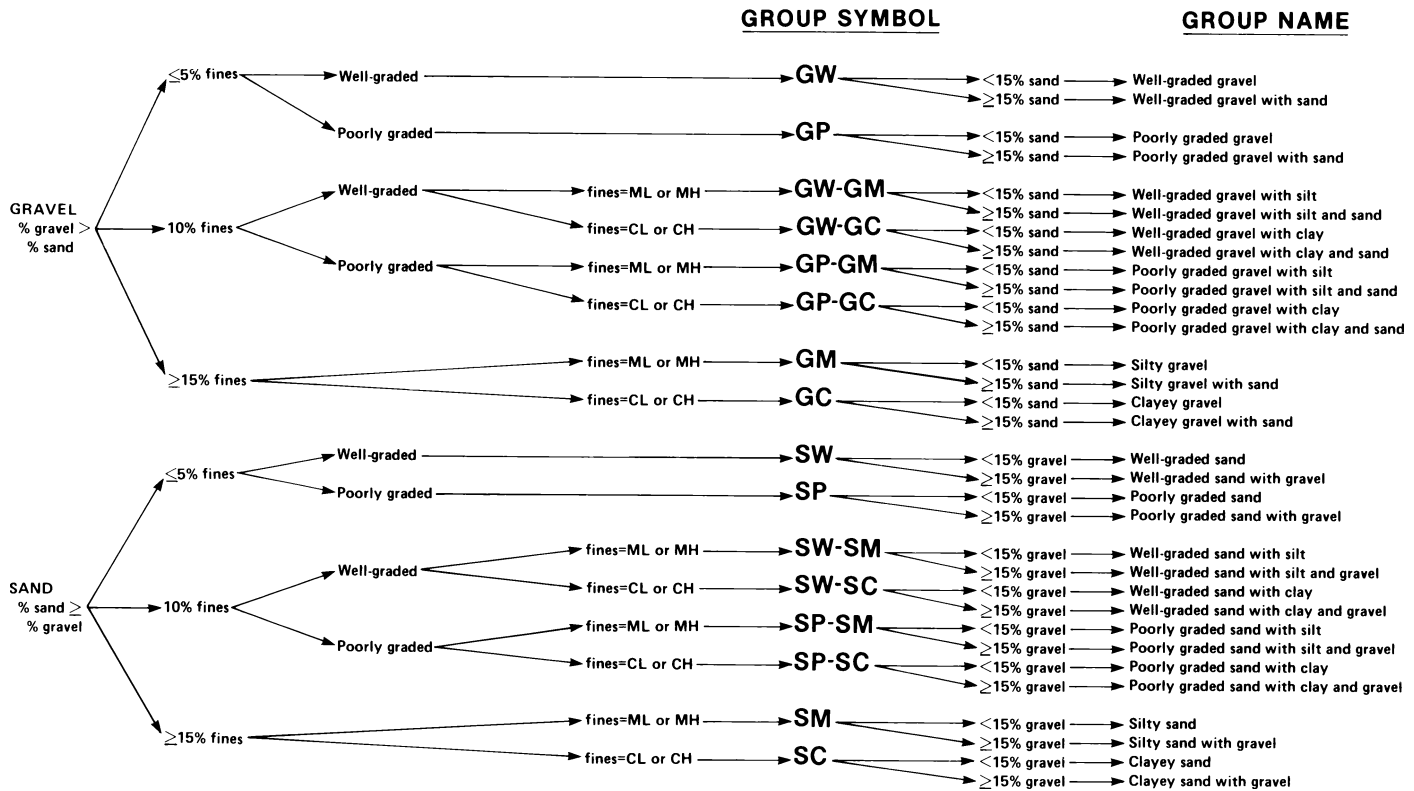
9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (¾ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the criteria in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the

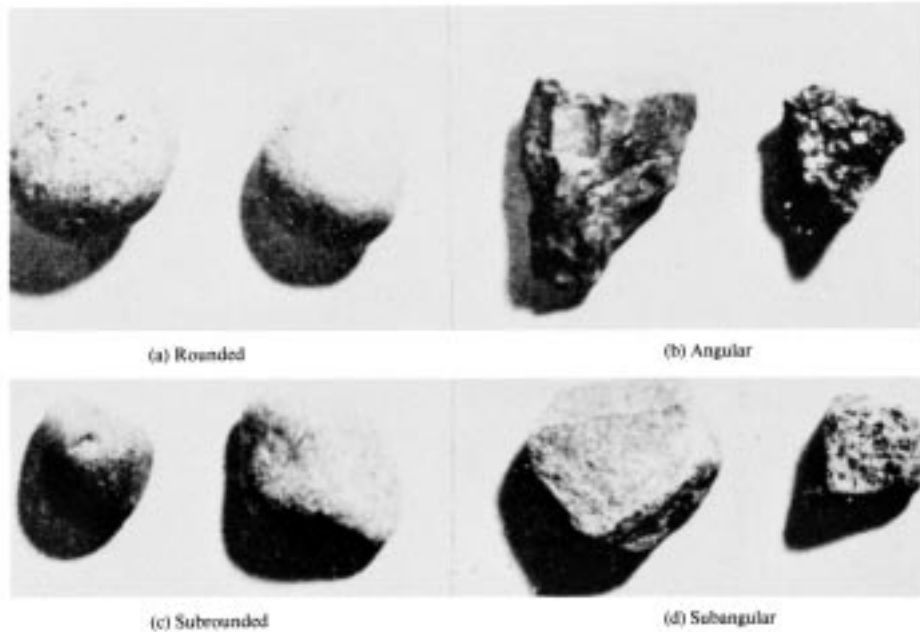


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

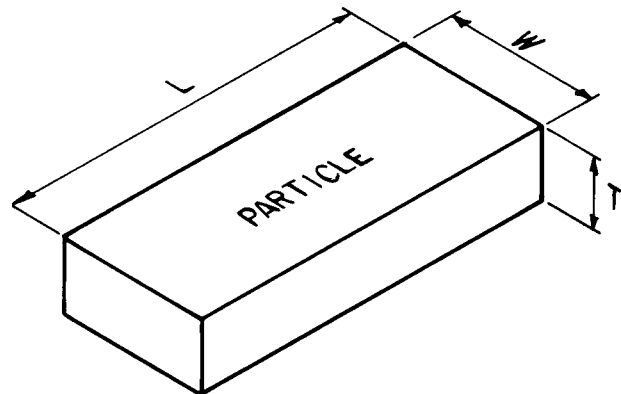
10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

PARTICLE SHAPE

W = WIDTH
T = THICKNESS
L = LENGTH



FLAT: $W/T > 3$
ELONGATED: $L/W > 3$
FLAT AND ELONGATED:
-meets both criteria

FIG. 4 Criteria for Particle Shape

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the

**TABLE 3 Criteria for Describing Moisture Condition**

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amor-

phous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 Dry Strength:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 Toughness:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 Identification of Inorganic Fine-Grained Soils:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 Identification of Organic Fine-Grained Soils:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness



TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words “with sand” or “with gravel” (whichever is more predominant) shall be added to the group name. For example: “lean clay with sand, CL” or “silt with gravel, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use “with sand.”

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words “sandy” or “gravelly” shall be added to the group name. Add the word “sandy” if there appears to be more sand than gravel. Add the word “gravelly” if there appears to be more gravel than sand. For example: “sandy lean clay, CL”, “gravelly fat clay, CH”, or “sandy silt, ML” (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use “sandy.”

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*,

SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words “with clay” or “with silt” to indicate the plasticity characteristics of the fines. For example: “well-graded gravel with clay, GW-GC” or “poorly graded sand with silt, SP-SM” (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words “with gravel” or “with sand” shall be added to the group name. For example: “poorly graded gravel with sand, GP” or “clayey sand with gravel, SC” (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words “with cobbles” or “with cobbles and boulders” shall be added to the group name. For example: “silty gravel with cobbles, GM.”

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
Gravel—fine, coarse
Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong
For intact samples:
18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.



NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log

forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft³; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as “Sandy Lean Clay (CL)”; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; “Poorly Graded Sand with Silt (SP-SM)”; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken



shells; about 30 % sand and sand-size shell pieces; about 10 % fines; “Poorly Graded Gravel with Sand (GP).”

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; “Poorly Graded Gravel (GP)” ; about 90 % fine,

hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay

ML/CL clayey silt

CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present.

The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:

Suffix:

s = sandy
g = gravelly

s = with sand
g = with gravel
c = with cobbles
b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name

Abbreviated

CL, Sandy lean clay
SP-SM, Poorly graded sand with silt and gravel
GP, poorly graded gravel with sand, cobbles, and boulders
ML, gravelly silt with sand and cobbles

s(CL)
(SP-SM)g
(GP)scb
g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993^{e1}) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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STANDARD OPERATING PROCEDURE

SEDIMENT GRAB SAMPLING

Introduction

Sediment grab samples are collected for the analysis of surficial sediment quality analyses (typically the 0-10 cm biologically active zone) for a variety of sediment investigations including sediment quality standard (SQS) chemical testing, NPDES mixing zone verification, and bioassay or benthic infauna investigations. Sediment grabs are collected using a variety of sampling equipment including a van Veen grab, Ekman grab, or petite Ponar sediment grab. Sediment grabs are collected by lowering the grab device through the water column, either by hand or under winch control, and the grab penetrates the sediment by means of its weight. The operation of individual grab samplers is not described in this SOP as individual grab types require different tripping mechanisms in the collection of sediments. The following steps outline the general procedure for the collection of sediment samples regardless of the specific grab sampler used.

Grab Sample Collection Procedures

1. Determine the appropriate equipment to be used for sediment collection requirements prior to field mobilization
2. Maneuver the sampling vessel to the proposed sampling location (within 3 meters) using the navigation system. The vessel operator should hold the vessel on location if possible to allow for the sediment collection by “live boating.” Alternatively, the vessel can be anchored using a 3 point anchoring array to hold position over the sample location.
3. Prior to sampler deployment, discuss safety issues involved in sample usage. Operators of grab equipment must be adequately familiar with grab and retrieval equipment usage prior to use. Practice grabs may be necessary for procedure familiarity.
4. Follow decontamination procedures of the grab sampler as outlined in the Sampling and Analysis Plan.

5. Ensure that deployment lines are free and clear and retrieval equipment is operational. Check that appropriate knots are prepared and that any mechanical retrieval equipment (davit and winch) are functioning properly.
6. Slowly lower the grab to the sediment surface. Too rapid deployment can cause the grab to sail off station or flip over. Deployment speeds can be adjusted according to various sediment types (i.e., soft sediments require a slower deployment to avoid over filling the grab devise).
7. Once on the bottom, give the grab sufficient slack to allow the tripping mechanism to release. In the case of the Ekman grab, maintain sufficient tension for the tripping messenger to glide smoothly along the line to trip the sampler.
8. When “live boating” maintain vertical control over the sampling position prior to lifting the grab so that the grab can be lifted vertically off the bottom. Begin to lift the sampler, either by hand (Ekman) or using the davit and winch on the vessel. Lifting the grab off the bottom will allow the jaws to close.
9. Upon retrieval of the grab to the water surface maintain ergonomic control, when hand lifting, to lift into the vessel or lift the grab high enough to place on a stable surface on the sampling vessel. When lifting onto the vessel, use care not to disturb the sample by banging against the side of the vessel.
10. After the grab sampler is retrieved aboard and placed in a stable position the sediment sample will be evaluated against Puget Sound Estuary Program (PSEP) sample acceptance protocols (PSEP 1997). PSEP acceptability criteria generally are listed in the SAP and include:
 - Sampler is not overfilled (i.e., there is no sediment surface against top doors of sampler
 - Sediment surface is relatively flat, indicating minimal disturbance or winnowing
 - Overlying water is present, indicating minimal leakage
 - Overlying water has low turbidity, indicating minimal sample disturbance
 - Desired penetration depth is achieved
11. When sample criteria are deemed sufficient, use a siphon hose, or turkey baster, to remove overlying water in the sampler to expose the sediment surface.
12. Follow Grab Sample Possessing procedures outline in SOP 2.2 and sample handling procedures outlined in SOP 4.1.

13. Photograph the sediment surface in the grab, note the GPS position, and follow the Sample Logging Procedures outlined in SOP Number 2.3.

Minimum Equipment Checklist

- Grab sampler with doors and weights
- Lines and pulleys
- Marker buoy with weight and line
- Siphon hose and/or turkey baster
- Decontamination equipment
- Stainless bowls and spoons for processing
- GPS and coordinates
- SAP and HSP
- Camera
- White board and marker
- Data logs
- Sample jars
- Sample labels
- Coolers and ice

References

- PSEP. 1997. Puget Sound Estuary Program (PSEP) 1997 manual: Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound

STANDARD OPERATING PROCEDURE

SPT AND SPLIT SPOON SAMPLING

Introduction

Soils can be sampled in a variety of ways. One way is with the use of a split spoon sampler advanced from a land- or water-based drill rig, and driven using the Standard Penetration Test (SPT). Split spoon sampling is generally used to collect disturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be extracted with a split spoon sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extracted. A split-spoon sample is ideal for collecting subsurface geotechnical data, including relative soil strength information through the SPT. When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D1586, "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils". This SOP describes the SPT and collection of soil samples using the split spoon.

Standard Penetration Test

The SPT is an approximate measure of soil density and consistency. To be useful, the results must be used with engineering judgment in conjunction with other tests. The SPT (as described in ASTM D 1586) is used to obtain disturbed soil samples. This test employs a standard 2-inch outside diameter split-spoon sampler. Using a 300-pound hammer, free-falling 30 inches, the sampler is driven into the soil for 18 inches. The number of blows required to drive the sampler the last 12 inches only is the Standard Penetration Resistance. This resistance, or blow count, measures the relative density of granular soils and the consistency of cohesive soils. The blow counts are plotted on the boring logs at their respective sample depths.

Soil samples are recovered from the split-barrel sampler, field classified, and placed into watertight jars or double bagged in ziplock bags. They are then shipped to the geotechnical laboratory for further testing.

In the Event of Hard Driving

Occasionally very dense materials preclude driving the total 18-inch sample. When this happens, the penetration resistance is entered on logs as follows:

Penetration less than six inches. The log indicates the total number of blows over the number of inches of penetration.

Penetration greater than six inches. The blow count noted on the log is the sum of the total number of blows completed after the first 6 inches of penetration. This sum is expressed over the number of inches driven that exceed the first 6 inches. The number of blows needed to drive the first 6 inches are not reported. For example, a blow count series of 12 blows for 6 inches, 30 blows for 6 inches, and 50 (the maximum number of blows counted within a 6-inch increment for SPT) for 3 inches would be recorded as 80/9.

Required Information on Boring Logs

Logs shall include the following information, at a minimum, to describe the drilling work:

1. Date and time of collection of each sample
2. Names of field personnel collecting and handling the samples
3. Type of sampling equipment used (i.e. split spoon diameter; hammer weight; free fall height; hammer deployment method)
4. Observations made during sample collection, including weather conditions, complications, and other details associated with the sampling effort
5. The sample station identification
6. Length and depth intervals of each sample and measured recovery
7. Qualitative notation of apparent resistance during driving
8. Any deviation from the approved SAP

Split Spoon Sample Collection and Processing

The following procedures are used for collecting soil samples with a split spoon:

1. Assemble the sampler by aligning both sides of barrel and then screwing the drive shoe on the bottom and the head piece on top.

2. Place the sampler in a perpendicular position on the sample material. Where a drill rig is used, this step is performed by the drilling contractor.
3. Use the SPT hammer to drive the tube. Do not drive past the bottom of the sample length. Where a drill rig is used, this step is performed by the drilling contractor.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, and the number of blows required to obtain this depth.
5. Withdraw the sampler, and open by unscrewing the bit and head and splitting the barrel. The amount of recovery and soil type should be recorded on the boring log. If a split sample is desired, a cleaned, stainless steel knife should be used to divide the tube contents in half, longitudinally. This sampler is typically available in 2 and 3 1/2 inch diameters. A larger barrel may be necessary to obtain the required sample volume.
6. Record soil description on the field log, and place samples in labeled, watertight containers.
7. Store sample in a dry location outside of direct sunlight.

Split Spoon Sample Logging

Split spoon samples will be logged on-site by an experienced field geologist or geotechnical engineer. Prior to sub-sampling, a description of each sample will be recorded on a standard boring log. The following parameters will be noted:

1. Sample recovery
2. Physical soil description in accordance with the Unified Soil Classification System (includes soil type, moisture, density/consistency of soil, color)
3. Odor (e.g., hydrogen sulfide, petroleum)
4. Visual stratification, structure, and texture
5. Vegetation and debris (e.g. woodchips or fibers, concrete , metal debris)
6. Biological activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
7. Presence of oil sheen

Standard terminology for field logs is attached to this SOP.

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:

Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

Density SAND or GRAVEL	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry Little perceptible moisture
Damp Some perceptible moisture, probably below optimum
Moist Probably near optimum moisture content
Wet Much perceptible moisture, probably above optimum

Minor Constituents





Estimated Percentage

Not identified in description 0 - 5
Slightly (clayey, silty, etc.) 5 - 12
Clayey, silty, sandy, gravelly 12 - 30
Very (clayey, silty, etc.) 30 - 50




Legends

Sampling Test Symbols

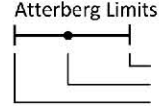
BORING SAMPLES

-  Split Spoon
-  Shelby Tube
-  Cuttings
-  Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

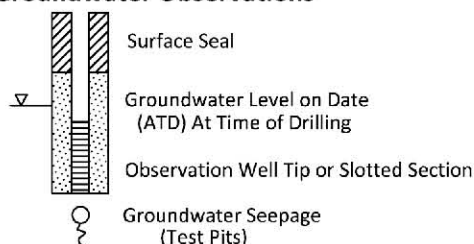
-  Grab (Jar)
-  Bag
-  Shelby Tube

Test Symbols

- GS Grain Size
- Comp Composite
- Chem Chemistry
- NS No Sheen
- SS Slight Sheen
- MS Moderate Sheen
- HS Heavy Sheen
- TCD Triaxial Consolidated Drained
- QU Unconfined Compression
- DS Direct Shear
- K Permeability
- PP Pocket Penetrometer
Approximate Compressive Strength in TSF
- TV Torvane
Approximate Shear Strength in TSF
- CBR California Bearing Ratio
- MD Moisture Density Relationship
- AL Atterberg Limits


Water Content in Percent
Liquid Limit
Natural
Plastic Limit
- PID Photoionization Detector Reading
- CA Chemical Analysis
- DT In Situ Density Test

Groundwater Observations



STANDARD OPERATING PROCEDURE

THIN WALL SAMPLING

Introduction

Soils can be sampled in a variety of ways. One way is with the use of a thin wall (a.k.a. Shelby tube) sampler advanced by hand, or hydraulically pushed from a land- or water-based drill rig. Thin wall sampling is generally used to collect undisturbed soil cores of 24 to 36 inches in length. A series of consecutive cores may be extracted with a thin wall sampler to give a complete soil column profile, or an auger may be used to drill down to the desired depth for sampling. The thin wall sampler is then pushed to its sampling depth through the bottom of the augured hole and the core extracted. A thin wall sampler is ideal for collecting relatively undisturbed subsurface geotechnical samples for advanced geotechnical laboratory testing. When thin wall sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D1587, "Thin-Walled Tube Sampling of Soils for Geotechnical Purposes". This SOP describes the collection of soil samples using the thin walled sampler.

Thin Wall Sample Collection and Processing

The following procedures are used for collecting soil samples with a thin-walled sampler:

1. Assemble the sampler by attaching the driving head to the sampling tube.
2. Place the sampler in a perpendicular position on the sample material. Where a drill rig is used, this step is performed by the drilling contractor.
3. Use a smooth continuous push to advance the tube. Do not drive past the bottom of the sample length. Where a drill rig is used, this step is performed by the drilling contractor.
4. Record in the site logbook or on field data sheets the length of the tube used to penetrate the material being sampled, as well as the detailed information described in this SOP.
5. Withdraw the sampler, and remove the drive head. The amount of recovery and soil type should be measured recording the depth to soil from both the top and bottom of the sample tube. Note any aberrations such as rocks or other objects visible in the drive end of the sampler.

6. Store sample upright in a protected and dry location outside of direct sunlight.

Required Information on Boring Logs

Logs shall include the following information, at a minimum, to describe the drilling work:

1. Date and time of collection of each sample
2. Names of field personnel collecting and handling the samples
3. Type of sampling equipment used (i.e. split spoon diameter; hammer weight; free fall height; hammer deployment method)
4. Observations made during sample collection, including weather conditions, complications, and other details associated with the sampling effort
5. The sample station identification
6. Length and depth intervals of each sample and measured recovery
7. Qualitative notation of apparent resistance during driving
8. Any deviation from the approved SAP

Thin Wall Sample Handling

Thin walled tube samples do not allow for direct observation or logging in the field. When recovered from the boring, the tubes will be measured for amount of recovery and checked to ensure the tube was not dented or damaged while driving or removing. The tubes will then be quickly cleaned, sealed with a plastic cap and duct tape on both ends, and labeled with boring name, sample name, date, approximate depth, and the location of the top of the sample with respect to the orientation it was removed from the subsurface. Every effort will be made to store and transport the Shelby tubes with minimal disturbance in the upright, vertical position. Split spoon samples will be logged on-site by an experienced field geologist or geotechnical engineer.

Standard terminology for field logs is attached to this SOP.

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:

Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

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Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry Little perceptible moisture
Damp Some perceptible moisture, probably below optimum
Moist Probably near optimum moisture content
Wet Much perceptible moisture, probably above optimum

Minor Constituents





Estimated Percentage

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Slightly (clayey, silty, etc.) 5 - 12
Clayey, silty, sandy, gravelly 12 - 30
Very (clayey, silty, etc.) 30 - 50




Legends

Sampling Test Symbols

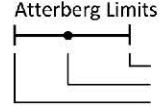
BORING SAMPLES

-  Split Spoon
-  Shelby Tube
-  Cuttings
-  Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

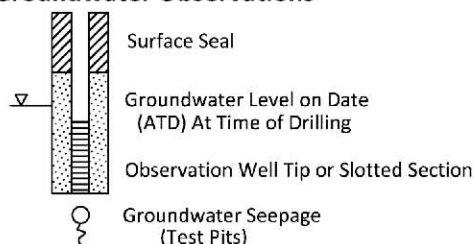
-  Grab (Jar)
-  Bag
-  Shelby Tube

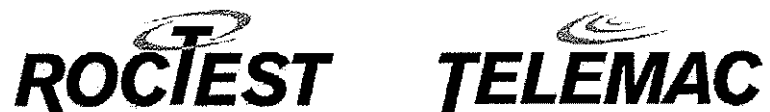
Test Symbols

- GS Grain Size
- Comp Composite
- Chem Chemistry
- NS No Sheen
- SS Slight Sheen
- MS Moderate Sheen
- HS Heavy Sheen
- TCD Triaxial Consolidated Drained
- QU Unconfined Compression
- DS Direct Shear
- K Permeability
- PP Pocket Penetrometer
Approximate Compressive Strength in TSF
- TV Torvane
Approximate Shear Strength in TSF
- CBR California Bearing Ratio
- MD Moisture Density Relationship
- AL Atterberg Limits


Water Content in Percent
Liquid Limit
Natural
Plastic Limit
- PID Photoionization Detector Reading
- CA Chemical Analysis
- DT In Situ Density Test

Groundwater Observations





INSTRUCTION MANUAL

FIELD INSPECTION VANE TESTER

Model H-60

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This product should be installed and operated only by qualified personnel. Its misuse is potentially dangerous. The Company makes no warranty as to the information furnished in this manual and assumes no liability for damages resulting from the installation or use of this product. The information herein is subject to change without notification.

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1 INTRODUCTION

The inspection vane borer is used to measure in situ undrained shear strength in clays. It is primarily intended for use in trenches and excavations at a depth not influenced by drying and excavation procedure.

When different sizes of vanes are used, the instrument range is from 0 to 260 kPa (0 to 26 t/m²). The accuracy of the instrument should be within 10% of the reading.

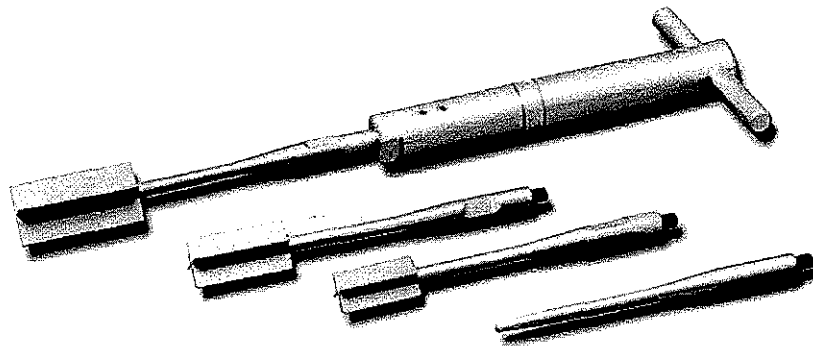


Figure 1: H-60 vanes in three different sizes

2 DESCRIPTION

The measurement part of the instrument is a spiral-spring (3). When the handle (1) is turned, the spring deforms and the upper part (4) and the lower part (8) of the instrument get a mutual angular displacement. The size of this displacement depends on the torque which is necessary to turn the vane (11). By means of a graduated scale (5) the shear strength of the clay is obtained (see Figure 2).

The lower and upper halves of the instrument are connected by means of threads. The scale (5) is also supplied with threads, and follows the upper part of the instrument by means of two lugs. The zero-point is indicated by a line on the upper part (4). When torque is applied, the scale-ring follows the upper part of the instrument, and when failure in the clay is obtained, the scale-ring (5) will remain in its position due to the friction in the threads.

Vane Diameter (mm)	Length	Area (horizontal)	Volume	Factor	Vane constants (Vc)	Capacity (T/m ²)	Capacity (kPa)
16	32	201.0624	6433.9968	1.95313	1.953	26	260
20	40	314.16	12566.4	1.00000	1.000	13	130
25.4	50.8	506.708664	25740.8001	0.48819	0.488	6.5	65
32	64	804.2496	51471.9744	0.24414	0.244	3.2	32.5
65	130	3318.315	431380.95	0.02913	0.029	0.4	3.9

The scale-ring is graduated either from 1 to 13 corresponding to T/m^2 or from 10 to 130 relating to kPa.

$$Sr = Vc \times \text{Scale Reading} \times (C. F. / 3.00 \text{ kgf cm})$$

where:

Sr	=	Undrain Shear Strength (in T/m^2 or kPa)
Vc	=	Vane Constant
Scale Reading	=	Units on the vane. (T/m^2 (*) or kPa)
C.F.	=	Calibration factor shown on the Calibration Data Sheet in kgf cm

(*) One unit theoretically corresponds to 1 T/m^2

The vane blades are soldered to a vane-shaft (9) which again is extended by one or more 0.5 m (0.49 m) long rods. The connection between the shaft-rods and the instrument is made by threads. To make the connections as straight as possible, the rods have to be screwed tight together and threads cleaned for dirt.

The maximum shear strength that can be measured with the inspection vane is 260 kPa (26 t/m^2). In clays with this shear strength a force of about 40 to 50 kilos is required to press the vane down into the clay. The vane-shaft is designed to take this force, but if extension rods are used, precautions against buckling are required.

3 INSTALLATION PROCEDURES

3.1 GENERAL PROCEDURES

1. Connect required vane (11) and extension rods to the inspection vane instrument.

N.B.: While screwing vane or rods to instrument, hold onto lower part.

2. Push vane into the ground to the required position.

N.B.: Do not twist inspection vane during penetration.

3. Make sure that the graduated scale (5) is set to zero-position.

4. Turn handle (1) clockwise.

N.B.: Be careful not to overturn.

5. When the lower part (8) follows the upper part (4) around or even falls back, failure and maximum shear strength is obtained in the clay at the vane.

6. Holding handle firmly, allow it to return to zero-position.

N.B.: Do not allow the handle to spring back uncontrolled.

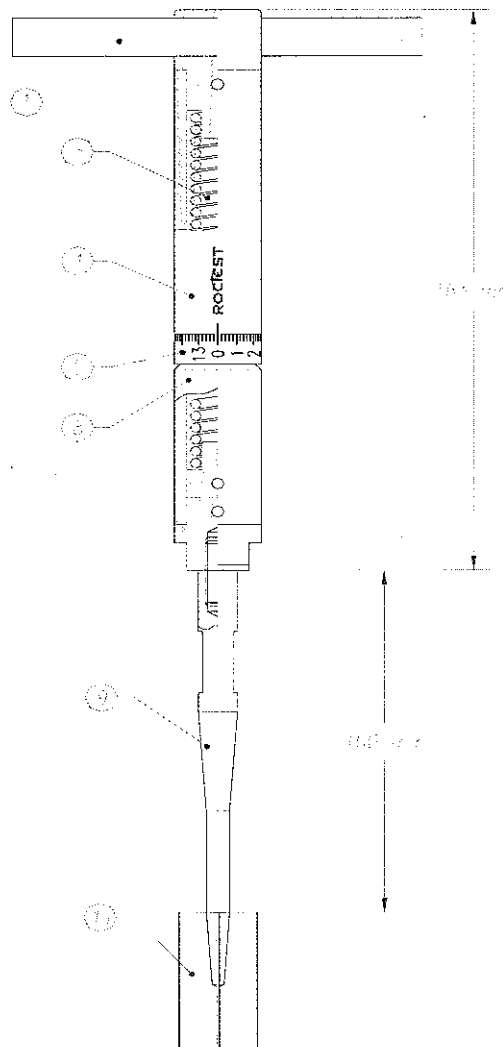


Figure 2: H-60 vane borer

7. Note the reading on the graduated scale.

N.B.: Do not touch or in any way disturb the position of the graduated ring until the reading is taken.

8. Write down the reading together with position of hole and depth.
9. Turn the graduated scale anti-clockwise back to zero-position.
10. To determine the remoulded shear strength, the following procedure is used:
 - Turn the vane quickly at least 25 revolutions. Do not turn using handle. Turn using wrenches provided.
 - Zero the scale and take at least two measurements by turning the instrument as slowly as possible.

- The minimum value is considered the correct one.
11. Push the vane down to next position. If necessary, screw on another extension rod.
 12. Repeat the above measurement procedure (3-10).
 13. When the last reading is taken, pull the vane up. If the clay is comparatively soft, this can be done by hand, gripping the handle. In harder clays, some mechanical device might be necessary. It is then advisable to connect this device directly to the connection rods (not to the instrument).

3.2 SPECIAL PROCEDURES

When measuring the shear strength at greater depths, the friction between the clay and the extension rods can be appreciable, and must be taken into consideration.

To measure this friction, extension rods and a vane-shaft without vane (dummy) are pushed into the ground to the depths required for shear force measurements. The friction is then measured in the same way as when using vanes (above 3-9). The friction-value thus obtained is used to evaluate the actual shear strength from the measured shear strength.

To penetrate through firm layers a pre-boring using a rod with the same diameter as the vane may be helpful.

4 MAINTENANCE

The H-60 vane borer is simply designed, and does not require much attention. But it is most important to keep it as clean as possible. Periodically, the instrument should be sent back to factory for recalibration.

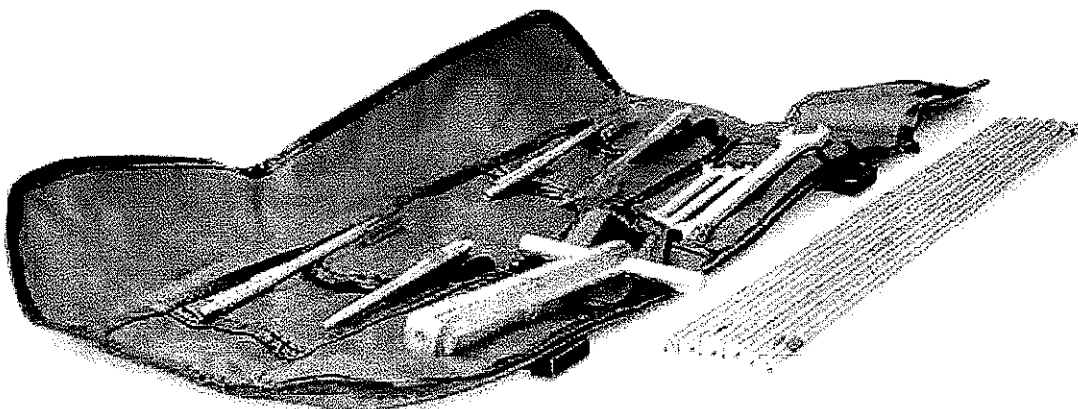


Figure 3: H-60 vane borer simple design

5 CONVERSION FACTORS

	To Convert From	To	Multiply By
LENGTH	Microns	Inches	3.94E-05
	Millimetres	Inches	0.0394
	Meters	Feet	3.2808
AREA	Square millimetres	Square inches	0.0016
	Square meters	Square feet	10.7643
VOLUME	Cubic centimetres	Cubic inches	0.06101
	Cubic meters	Cubic feet	35.3357
	Litres	U.S. gallon	0.26420
	Litres	Can-Br gallon	0.21997
MASS	Kilograms	Pounds	2.20459
	Kilograms	Short tons	0.00110
	Kilograms	Long tons	0.00098
FORCE	Newtons	Pounds-force	0.22482
	Newtons	Kilograms-force	0.10197
	Newtons	Kips	0.00023
PRESSURE AND STRESS	Kilopascals	Psi	0.14503
	Bars	Psi	14.4928
	Inches head of water*	Psi	0.03606
	Inches head of Hg	Psi	0.49116
	Pascal	Newton / square meter	1
	Kilopascals	Atmospheres	0.00987
	Kilopascals	Bars	0.01
	Kilopascals	Meters head of water*	0.10199
TEMPERATURE	Temp. in °F = (1.8 x Temp. in °C) + 32		
	Temp. in °C = (Temp. in °F - 32) / 1.8		

* at 4 °C

E6TabConv-990505

Table 1: Conversion factors

ATTACHMENT A3

FIELD FORMS

LIST OF FIELD FORMS

Surface Sediment/Soil Collection Form

Sediment Core Log

Chain of Custody/Laboratory Analysis Request Form

Field Change Request and Corrective Action Record

Soil Boring Processing Log

Vane Shear Log

SURFACE SEDIMENT/SOIL COLLECTION FORM

Project Name: _____		Project No. _____		Page: _____	
Date: _____ Crew: _____					
Weather: _____					
Sampling Method: _____					

Time: _____		Station: _____		Replicate: _____		Acceptable grab: <input type="checkbox"/> Yes <input type="checkbox"/> No	
Bottom Depth: _____		Penetration Depth: _____		RPD Depth: _____			
Analyses before homogenization:		<input type="checkbox"/> VOC		<input type="checkbox"/> Sulfides		<input type="checkbox"/> Other	
Sample ID: _____							
Type: <input type="checkbox"/> cobble <input type="checkbox"/> gravel <input type="checkbox"/> sand C M F <input type="checkbox"/> silt clay <input type="checkbox"/> organic matter <input type="checkbox"/> wood/shell fragments							
Color: <input type="checkbox"/> drab olive <input type="checkbox"/> gray <input type="checkbox"/> black <input type="checkbox"/> brown <input type="checkbox"/> brown surface							
Odor: <input type="checkbox"/> none <input type="checkbox"/> slight <input type="checkbox"/> moderate <input type="checkbox"/> strong <input type="checkbox"/> sulfidic <input type="checkbox"/> petroleum <input type="checkbox"/> other							
Comments: _____							

Time: _____		Station: _____		Replicate: _____		Acceptable grab: <input type="checkbox"/> Yes <input type="checkbox"/> No	
Bottom Depth: _____		Penetration Depth: _____		RPD Depth: _____			
Analyses before homogenization:		<input type="checkbox"/> VOC		<input type="checkbox"/> Sulfides		<input type="checkbox"/> Other	
Sample ID: _____							
Type: <input type="checkbox"/> cobble <input type="checkbox"/> gravel <input type="checkbox"/> sand C M F <input type="checkbox"/> silt clay <input type="checkbox"/> organic matter <input type="checkbox"/> wood/shell fragments							
Color: <input type="checkbox"/> drab olive <input type="checkbox"/> gray <input type="checkbox"/> black <input type="checkbox"/> brown <input type="checkbox"/> brown surface							
Odor: <input type="checkbox"/> none <input type="checkbox"/> slight <input type="checkbox"/> moderate <input type="checkbox"/> strong <input type="checkbox"/> sulfidic <input type="checkbox"/> petroleum <input type="checkbox"/> other							
Comments: _____							

Time: _____		Station: _____		Replicate: _____		Acceptable grab: <input type="checkbox"/> Yes <input type="checkbox"/> No	
Bottom Depth: _____		Penetration Depth: _____		RPD Depth: _____			
Analyses before homogenization:		<input type="checkbox"/> VOC		<input type="checkbox"/> Sulfides		<input type="checkbox"/> Other	
Sample ID: _____							
Type: <input type="checkbox"/> cobble <input type="checkbox"/> gravel <input type="checkbox"/> sand C M F <input type="checkbox"/> silt clay <input type="checkbox"/> organic matter <input type="checkbox"/> wood/shell fragments							
Color: <input type="checkbox"/> drab olive <input type="checkbox"/> gray <input type="checkbox"/> black <input type="checkbox"/> brown <input type="checkbox"/> brown surface							
Odor: <input type="checkbox"/> none <input type="checkbox"/> slight <input type="checkbox"/> moderate <input type="checkbox"/> strong <input type="checkbox"/> sulfidic <input type="checkbox"/> petroleum <input type="checkbox"/> other							
Comments: _____							

Time: _____		Station: _____		Replicate: _____		Acceptable grab: <input type="checkbox"/> Yes <input type="checkbox"/> No	
Bottom Depth: _____		Penetration Depth: _____		RPD Depth: _____			
Analyses before homogenization:		<input type="checkbox"/> VOC		<input type="checkbox"/> Sulfides		<input type="checkbox"/> Other	
Sample ID: _____							
Type: <input type="checkbox"/> cobble <input type="checkbox"/> gravel <input type="checkbox"/> sand C M F <input type="checkbox"/> silt clay <input type="checkbox"/> organic matter <input type="checkbox"/> wood/shell fragments							
Color: <input type="checkbox"/> drab olive <input type="checkbox"/> gray <input type="checkbox"/> black <input type="checkbox"/> brown <input type="checkbox"/> brown surface							
Odor: <input type="checkbox"/> none <input type="checkbox"/> slight <input type="checkbox"/> moderate <input type="checkbox"/> strong <input type="checkbox"/> sulfidic <input type="checkbox"/> petroleum <input type="checkbox"/> other							
Comments: _____							

SEDIMENT CORE LOG

PROJECT: San Jacinto River Waste Pits

Core ID: pg ____ of ____

<u>Collected:</u>	<u>Processed:</u>
Date: ___ / ___ /2010 Drive Length: _____	Date: ___ / ___ /2010
Time: _____ Tide Level (CRD): _____	Time: _____
Recovery Length: _____ Mudline Depth: _____	Core Length: _____
Recovery Efficiency: _____ Vessel: _____	Location: _____
Crew: _____	Crew: _____

[illegible]

Core segment breaks at (cm):

Page of

Turn Around Requested:

[illegible]

	FIELD CHANGE REQUEST	Project Number:
Project Number: Project Name:		Field Change No. Page _____ to
CHANGE REQUEST Applicable Reference: Description of Change: Reason for Change: Impact on Present and Completed Work: <div style="display: flex; justify-content: space-between;"> <div> (Field Scientist) (Field Task Leader) </div> <div> Requested by: Date: ____/____/____ Acknowledged by: Date: ____/____/____ </div> </div>		
FIELD OPERATIONS MANAGER RECOMMENDATION Recommended Disposition: <div style="display: flex; justify-content: flex-end;"> Recommendation by: Date: ____/____/____ </div> <div style="text-align: center;"> (Sampling and Analysis Coordinator) </div>		
PROJECT MANAGER APPROVAL Final Deposition: <div style="display: flex; justify-content: flex-end;"> Approved/Disapproved by: Date: ____/____/____ </div> <div style="text-align: center;"> (CERCLA Coordinator) </div>		

CORRECTIVE ACTION RECORD

Page ____ of

Audit Report No. : _____ Date:

Report Originator:

Person Responsible for Response:

DESCRIPTION OF PROBLEM:

Date and Time Problem Recognized: _____ By:

Date of Actual Occurrence: _____ By:

Analyte: _____ Analytical Method:

Cause of Problem:

CORRECTIVE ACTION PLANNED:

Person Responsible for Corrective Action:

Date of Corrective Action:

Corrective Action Plan Approval: _____ Date:

DESCRIPTION OF FOLLOW-UP ACTIVITIES:

Person Responsible for Follow-up Activities:

Date of Follow-up Activity:

Final Corrective Action Approval: _____ Date:

Soil Boring Processing Log



Boring Location:										Boring _____ Date _____		Sheet _____ of _____	
										Job <u>San Jacinto Waste Pits</u>		Job No. <u>090557-01</u>	
										Logged By _____		Weather _____	
										Drilled By _____			
										Drill Type/ Method _____			
										Sampling Method _____			
Elevation: _____ Datum: _____										Bottom of Boring _____		ATD Water Level Depth _____	
Obs. Well Install.				Yes <input type="checkbox"/>		No <input type="checkbox"/>							
SIZE (%)			Time / PID	DEPTH		SAMPLE		DEPTH/ SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION: Den., moist., color, minor, MAJOR CONSTITUENT, NON-SOIL SUBSTANCES: Odor, staining, sheen, scrag, slag, etc.	REMARKS: Drill action, drill and sample procedures, water conditions, heave, etc.	SUMMARY LOG (Water & Date)	
G	S	F		From	To	Type	Number						
Max.	Range	Att. Limits											
								0					
								1					
								2					
								3					
								4					
								5					
								6					
								7					
								8					
								9					
								10					
								11					
								12					
								13					
								14					
								15					
								16					
								17					
								18					
								19					
								20					

Vane Shear Log

Project: San Jacinto Waste Pits 090557-01

Location: _____

Technician: _____

Date: _____

ROCTEST M-3 Vane Tester	
<u>Vane Diameter</u>	<u>Vane constant</u>
25.4mm (1")	0.488
32mm (1.25")	0.244
65mm (2.56")	0.029

[illegible]

Note - 1 kPa = 20.89 psf

ATTACHMENT A4
USEPA RISK ASSESSMENT
GUIDANCE FORMS (PER THE
UNILATERAL ADMINISTRATIVE
ORDER STATEMENT OF WORK)

EXHIBIT 5
USEPA SAMPLING DESIGN
SELECTION WORKSHEETS

Exhibit 5. Part I: Medium Sampling Summary Sampling Design Selection Worksheet

A. Site Name San Jacinto River Waste Pits **B. Base Map Code**

C. Medium: Groundwater, Soil, Sediment, Surface Water, Air or Other (specify) Sediment

D. Comments

1. The number of subsurface sediment samples that will be collected during this study is not included in this form. The number of sediment samples that will be collected from each core will vary and will be unknown until the time of sample collection. Sediment samples will be collected from 11 locations from each 1-foot interval to a maximum depth of 10 feet (exact depth will vary at each station).
2. Samples that will be collected for geotechnical and engineering analyses will not be used in the risk assessment and are therefore not included on these worksheets.

E. Medium/ Pathway Code	Exposure Pathway/ Exposure Area Name	F. Number of Samples from Part II					
		Judgmental/ Purposive	Background	Statistical Design	Geometrical or Geostatistical Design	QC	Row Total
Sediment	Nature and extent	59	11	NA	NA	32	102
Sediment	Human health risk assessment	30	10	NA	NA	16	56
Sediment	Ecological risk assessment	9	3	NA	NA	6	18
Column Totals:		98	24	NA	NA	54	176
G. Grand Total:							176

Exhibit 5. Part II: Exposure Pathway Summary
Sampling Design Selection Worksheet (cont'd.)

H. Radionuclide of Potential Concern and CAS Number	I. Frequency of Occurrence	J. Estimation		K. CV	L. Background
		Arithmetic Mean	Maximum		
NA	NA	NA	NA	NA	NA

M. Code (CAS Number) of Radionuclide of Potential Concern Selected as Proxy NA

N. Reason for Defining New Stratum or Domain (check one)

- ☐ Heterogeneous Radionuclide Distribution
☐ Geological Stratum Controls
☐ Historical Information Indicates Difference
☐ Field Screening Indicates Difference
☐ Exposure Variations
☒ Other (specify) NA

Q. Stratum or Exposure Area	P. Reason	Q. Number of Samples from Part III					
		Judgmental/ Purposive	Background	Statistical Design	Geometrical or Geostatistical Design	QC	Row Total
Sediment	Nature and extent	59	11	NA	NA	32	102
Sediment	Human health risk assessment	30	10	NA	NA	16	56
Sediment	Ecological risk assessment	9	3	NA	NA	6	18
R. Total (Part I, Step F):		24	NA	NA	NA	54	176

Exhibit 5. Part III: Exposure Area Summary

Sampling Design Selection Worksheet (cont'd.)

O. Stratum or Exposure Area San Jacinto River Waste Pits Domain Code _____
 E. Medium/Pathway Code Sediment Pathway Code _____

S. Judgmental or Purposive Sampling

Comments

Use prior site information to place samples, or determine location and extent of contamination. Judgmental or purposive samples generally cannot be used to replace statistically located samples. An exposure area and stratum MUST be sampled by at least TWO samples.

Number of Samples

176

T. Background Samples

Background samples must be taken for each medium relevant to each stratum/area. Zero background samples are not acceptable. See the discussion on pp. 74-75 of Guidance for Data Useability in Risk Assessment Part A.

Number of Background Samples

24

U. Statistical Samples

CV of proxy or radionuclide of potential concern

NA

Minimum Detectable Relative Difference (MDRD)

NA

(<40% if no other information exists)

Confidence Level NA (>80%)

Power of Test

NA (>90%)

Number of Samples (See formula in Appendix IV)

NA

V. Geometrical Samples

Hot spot radius

NA

Enter distance units)

NA

Probability of hot spot prior to investigation

NA

(0 to 100%)

Probability that NO hot spot exists after investigation
(See formula in Appendix IV)

NA

(enter only if >75%)

W. Geostatistical Samples

Required number of samples to complete grid + number of short range samples

NA

X. Quality Control samples

Number of Duplicates (Minimum 1:20 environmental samples)

27

Number of Blanks (Minimum 1 per medium per day or 1 per sampling process, whichever is greater)

26

Y. Sample Total for Stratum (Part II, Step U)

Judgmental/ Purposive	Background	Statistical Design	Geometrical or Geostatistical Design	QC	Row Total
98	24	NA	NA	54	172

EXHIBIT 52

METHOD SELECTION WORKSHEET

Exhibit 52. Method Selection Worksheet

I. Analytes		II. Medium	III. Critical parameters				IV. Routine Available Methods ⁴
A. Chemical or Class of Chemicals of Potential Concern	B. Reporting Requirement ¹ (Y/N)		A. Turnaround Time (enter hours or days)	B. ID Only or ID Plus Quant (ID or ID+Q)	C. Concentration of Concern (or PRG) ²	D. Required Method Detection Limit ³	
Dioxins/furans	N	Sediment	21 days	ID+Q	2,3,7,8-TCDD TEQ of 3.11 ng/kg	Not applicable	1613B / 8290A
Aluminum	N	Sediment	21 days	ID+Q	31 mg/kg	6.2 mg/kg	6010B / 6020
Copper	N	Sediment	21 days	ID+Q	2.4 mg/kg	0.48 mg/kg	6010B / 6020
Magnesium	N	Sediment	21 days	ID+Q	726 mg/kg	145 mg/kg	6010B / 6020
Thallium	N	Sediment	21 days	ID+Q	1.6 mg/kg	0.32 mg/kg	6010B / 6020
Mercury	N	Sediment	21 days	ID+Q	0.06 mg/kg	0.012 mg/kg	7471A
Carbazole	N	Sediment	21 days	ID+Q	220 µg/kg	44 µg/kg	8270C
2,3,4,6- Tetrachlorophenol	N	Sediment	21 days	ID+Q	1,800,000 µg/kg	360,000 µg/kg	8270C
Chloroform	N	Sediment	21 days	ID+Q	300 µg/kg	60 µg/kg	8260B

¹Y = total reported for compound class

N = each analyte reported separately

²Preliminary remediation goal

³Method detection limit should be no greater than 20% of concentration of concern

⁴Refer to Appendix III for specific methods. Recommend consultation with chemist and/or automated methods search to determine all methods available. (Exhibit 53 lists computer systems that support method selection.